IRON STATUS OF NEONATES BORN TO IRON DEFICIENT ANEMIC MOTHERS

Dissertation submitted in partial fulfillment of the Requirement for the award of the Degree of

M.D. (PAEDIATRIC MEDICINE)

BRANCH – VII

DEPARTMENT OF PAEDIATRIC MEDICINE,

TIRUNELVELI MEDICAL COLLEGE,

TIRUNELVELI - 620711.

THE TAMILNADU

DR.M.G.R.MEDICAL UNIVERSITY,

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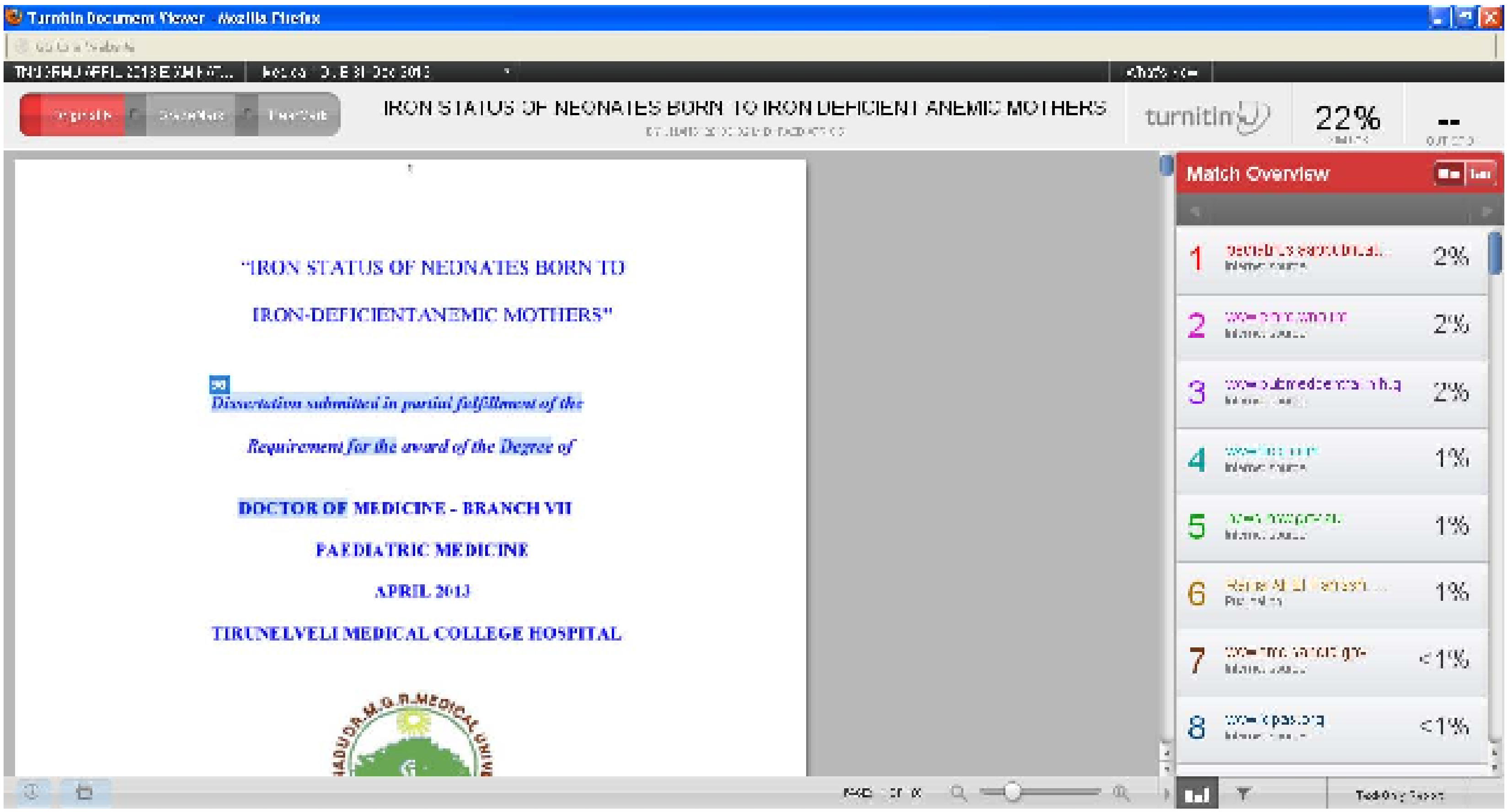
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Prof.Dr.M. GEETHANJALI MD.,
Unit Chief, UNIT III
Department of Paediatrics,
Tirunelveli Medical College ,
Tirunelveli – 627011.

Prof. Dr.S. DEVIKALA,MD.,
Professor and HOD,
Department of paediatrics,
Tirunelveli Medical College,
Tirunelveli – 627011.

The Dean
Tirunelveli Medical College,
Tirunelveli – 627 011.

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I, **Dr.R.JHANSI**, solemnly declare that the Dissertation titled **"IRON STATUS OF NEONATES BORN TO IRON DEFICIENT ANEMIC MOTHERS"** has been prepared by me.

This is submitted to the Tamilnadu Dr.M.G.R. Medical University, Chennai, in partial fulfillment of the regulations for the award of MD Degree Branch VII (PAEDIATRICS). It was not submitted to the award of any degree/diploma to anyUniversity either in part or in full previously.

Place: Tirunelveli **Dr.R.JHANSI**

Date

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TIRUNELVELI MEDICAL COLLEGE

TIRUNELVELI,

STATE OF TAMILNADU, INDIA

PIN CODE:627011

Tel. 91-462-2572733, 2572734 Fax: 91 462 2572944

Estd: 1965

Under the Directorate of Medical Education, Government of Tamilnadu.

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ABBREVIATIONS

RBC -Red Blood Cell

HB-Hemoglobin

MCV- Mean Corpuscular Volume

MCH- Mean Corpuscular Hemoglobin

MCHC-Mean Corpuscular Hemoglobin Concentration

HCT- Hematocrit

TIBC- Total Iron Binding Capacity

RDW-Red cell Distribution Width

ZPP-Zinc ProtoPorphyrin

Tfr- Transferrin receptor

WHO- World Health Organisation

ICMR- Indian Council of Medical Research

CDC- Center for Disease Control

NNACP- National Nutrition and Anemia Control Programme

ANOVA- Analysis Of Variance

HC- Head Circumference

CC- Chest Circumference

INTRODUCTION

Anemia is one of the major public health problems in the developing world. More than 70% of pregnant women in South-East Asia region suffer from nutritional anemia.[1]

Iron deficiency anemia is the most common nutritional deficiency in pregnancy, with an impact on fetal and maternal morbidity and mortality. It is regarded as the most important preventable cause of some perinatal complications, such as preterm delivery, intrauterine growth retardation, neonatal and perinatal mortality.[2, 3]

It is still not clear whether deficient iron stores in pregnant women might lead to a deficient iron status of their children. Many studies conducted till now have supported the belief that iron transport from the pregnant women to their fetus occurs independently of maternal iron levels. These studies also point out that it might even induce deficiency in the pregnant women as a result of fetal "parasitism"[4, 5, 6]. However, many studies conducted later , have questioned this belief and suggested that iron deficiency in the mother can cause depletion of iron stores in the fetus [7,8,9,10,11] . No consensus has been reached regarding this subject so far.

The difficulty in establishing a correct diagnosis of the iron status of pregnant women represents a major complicating factor in the understanding of the relationship between the maternal and fetal iron levels. The physiological changes that occur during the pregnancy (expanding plasma volume and erythropoiesis) have a significant impact on the hematological and biochemical parameters available for the assessment of iron status in pregnancy. Hemoglobin estimation is the most commonly used parameter to detect anemia in public health care services because of its low cost and the available reference standards. Therefore, a combination of multiple parameters has been proposed in order to improve the diagnosis of iron deficiency in pregnant women[12,13].

In this study, I have made an attempt to study the relationship between the iron status of pregnant women and their neonates using some parameters for the diagnosis of iron deficiency.

AIM AND OBJECTIVES

Aim

To determine the relationship between the iron status of pregnant women and their newborns using a combination of hematologic and biochemical parameters for the diagnosis of iron- deficiency.

Objectives

1. To find the correlation between the hemoglobin, hematocrit, RBC indices, serum iron and serum ferritin levels of the mothers with their hemoglobin levels.
2. To find the correlation between the hemoglobin, RBC Indices, serum iron and serum ferritin levels of the neonates with the maternal hemoglobin levels.
3. To find the correlation between the maternal and neonatal RBC indices and the maternal and neonatal iron stores.
4. To find the correlation between the neonatal anthropometric measurements and the maternal hemoglobin levels.

REVIEW OF LITERATURE

In the developing countries, anemia is one of the major public health problems in all the age groups. Of these, the most vulnerable group is pregnant women. There are various causes of anemia in pregnant women. Among the various causes, nutritional anemia is the commonest one, particularly in developing countries like India. In South-East-Asia region, more than 70% of pregnant women suffer from nutritional anemia.[1]

Iron-deficiency anemia is the commonest nutritional anemia affecting pregnant women. It may antedate conception, often aggravated by pregnancy and delivery. One of the primary aims of antenatal care is to prevent and treat anemia during pregnancy, since the safety of labour and the puerperal state, and the delivery of a healthy newborn and Neuro-Developmental outcome depend upon the state of the patient's hematological reserve.

Even though regular iron supplementation is routinely recommended by the health care systems in our country, this advice is often ignored making the pregnant women deficient in iron stores. The transfer of iron from the pregnant women to the fetus occurs across the placenta against a concentration gradient. Iron from the mother is the only source for the fetus; it is very clear that, iron status of the mother will affect the iron status of the neonate.

Various studies have been conducted till now, to investigate the relationship between the mother and the neonate with regard to the iron status. Based on the results some studies point out that, no significant relationship exists [14].

Rest of the studies point out that, severe iron deficiency in the pregnant women has been shown to adversely affect iron status of the neonate and thereby the subsequent growth and development of the infant[15]. This study was carried out to determine the relationship between the maternal and neonatal Iron status.

Definition

The World Health Organisation (WHO) defines anemia in healthy non-pregnant women as 12g/dl, whereas in pregnant women it is defined as hemoglobin level below 11g/dl[16].

The Center for Disease Control (CDC) recommends that hemoglobin in pregnant women should not be allowed to fall below 10.5g/dl in the second trimester, taking into account the physiological changes of pregnancy[17].

In India, hemoglobin level less than 10g/dl is considered as anemia as defined by the Federation of Obstetrics and Gynecological society of India[18].

Classification of anemia:

Classification of Anemia (Indian Council Of Medical Research, 1989)[19] Hemoglobin level Classification

- <4g/dl Very severe
- 4-6.9 g/dl Severe
- 7-9.9 g/dl Moderate
- 10-10.9 g/dl Mild

Prevalence of anemia:

Prevalence of anemia in India is higher than other countries in the world. In India, the most affected groups are the pregnant women and preschool children. WHO has estimated the prevalence of anemia in pregnant women is 14 percent in developed and 51 percent in developing countries and 65-75 percent in India[20]. About one third of the global population (over 2 billion) are anemic[21]. In India, anemia prevalence in all the age groups are higher when compared to other developing countries.

In the world, prevalence of anemia is very high in South-East-Asian countries. WHO estimates that even among the South-East-Asian countries , prevalence is highest in India. The most important fact is that, South-East-Asian contribute to half of the maternal deaths in the world. Among these deaths, India contributes to eighty percent.[22].

Table. 1

Prevalence of Anemia in South-East-Asia[22]

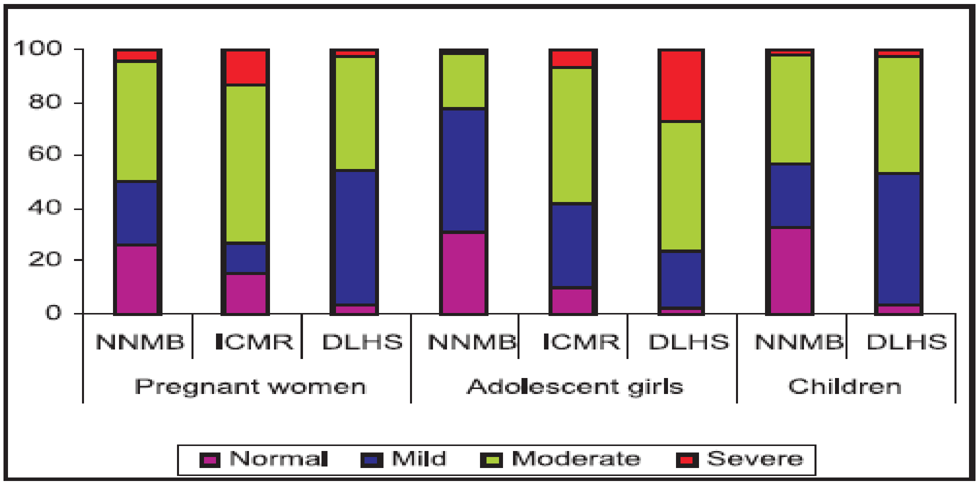
Country	Prevalence of anemia in percentage
Afghanistan	–
Bangladesh	74
Bhutan	68
India	87
Nepal	63

Available estimates also suggest that the magnitude of reduction in the prevalence of anemia during the nineties in India is lower than that in neighbouring South East Asian countries.

The surveys conducted by National Nutrition Monitoring Bureau (NNMB)[23], District Level Household Survey (DLHS)[24], Indian Council of Medical Research (ICMR) [19]showed that over 70% of pregnant women and adolescent girls in the country were anemic. (Fig 1)

Figure. 1[23,24,19]

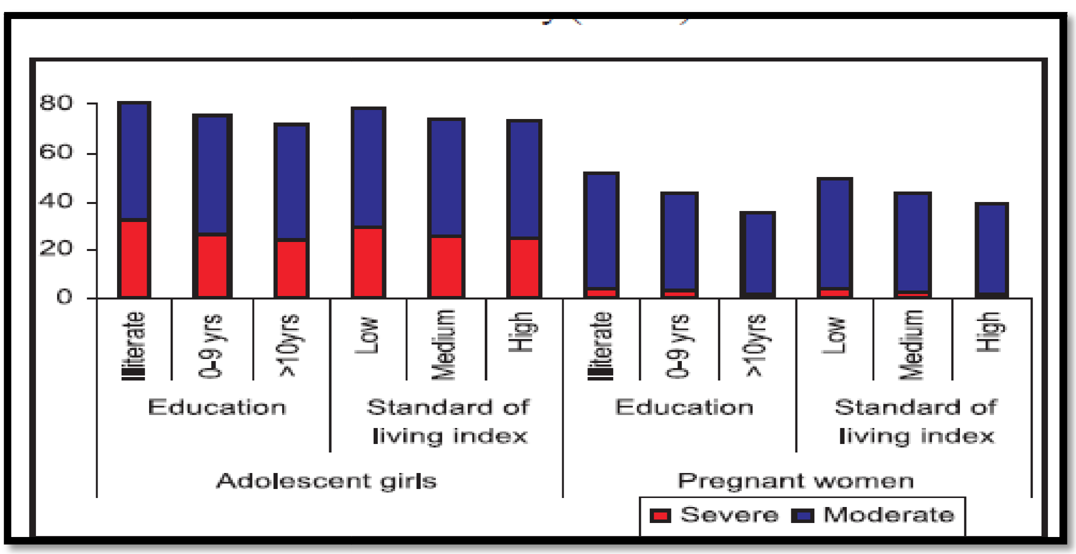
Prevalence of anemia in pregnant women



Data from DLHS showed that prevalence of moderate and severe anemia were high even among educated and higher income groups. (Fig 2)

Figure. 2[24]

Prevalence of Anemia In Different Socioeconomic groups



Factors responsible for high prevalence of Anemia

In India, the high prevalence of Anemia is due to the following factors:

- Low dietary intake of iron and folic acid (iron< 20mg/day and folic acid <70ug/day)
- Poor bioavailability of iron (3-4% only) in fibre and phytate rich diet.
- Infections such as malaria and hookworm causing chronic blood loss.

Iron and Folic acid intake in the country is very low in all the age groups according to the surveys conducted by National Nutrition Monitoring Bureau (NNNB)[23,25].

Because of all the above mentioned facts, the adolescent girls have low iron stores. When they become pregnant, their iron stores will fall further making them iron-deficient. The absorption of iron in pregnant women is assumed to be 8%. Even then their dietary requirement will meet only 30 % to 45% of this requirement.

The low dietary intake of iron, folic acid and food materials promoting iron absorption, coupled with low bioavailability of iron are the major factors contributing to the high prevalence of iron deficiency anemia in our country[26,27].

Anemic mothers with low iron stores give birth to children with low iron stores and their breast milk contain low iron .Obviously when these infants are not fed with iron rich nutritious foods they will have anemia in childhood itself[28].

With the onset of menstruation and chronic blood loss, the prevalence of anemia in adolescent girls and its severity go high. Early marriage and adolescent pregnancy aggravate anemia and their offspring will have low iron stores. Therefore, in Indian population there is an intergenerational self-perpetuating vicious cycle of anemia[24] .

Physiological changes in the red cell count during pregnancy

Hemoglobin concentrations less than 12g/dl and hematocrit below 36%, which define anemia in the general population, are not indicative of anemia in pregnant patients because of a physiologic change called “hemodilution of pregnancy”. This phenomenon was described by Scott and Pritchard (1967)[29] who measured the hemoglobin/hematocrit (H/H) concentrations of a large group of healthy young women with proven normal iron and folate stores. They found an average drop in hematocrit of 5 U for a singleton and 7U for a twin pregnancy during the second trimester of pregnancy. This is a consequence of the intravascular volume expansion which starts at 8-10 weeks of gestation and reaches its maximum during the second trimester.

The red blood cell (RBC) mass increases by 30%, whereas the plasma volume increases by 40% to 50%, resulting in erythrocyte dilution by 5% to 15% and a decrease in hemoglobin concentration by approximately 2g/dl [30]. The peripheral smear however remains normochromic and normocytic. This phenomenon is regarded as the "physiologic anemia of pregnancy".

This phenomenon makes the blood less viscous so that it reduces the load on the heart and it can easily pass through the placenta. The increased blood volume also protects against the blood loss occurring in the third stage of labour. But this is not always beneficial. In patients with cardiac disease, the increased circulatory blood volume can be dangerous. The physiological dilution should never be allowed to fall to the level of anemia. If it occurs, it should be corrected before term.

EFFECTS OF ANEMIA ON THE MOTHER

Maternal Mortality

Anemia is one of the most important contributor to maternal mortality in our country. Depending on the available obstetric care and the severity of anemia, the case fatality rates vary from <1% to > 50%[31]. In cases of severe anemia, the cause of death is mostly due to cardiac failure. Anemia is accounting for 17% of maternal deaths in India and the case fatality rate for anemia in pregnancy is 6-17%[19].

Maternal morbidity

- Anemia aggravates all the complications of pregnancy, particularly cardiac diseases. It increases dyspnoea in cardiac patients.
- It depresses the immune system in pregnant women, making hem prone to many infections, particularly asymptomatic bacteriuria[26,27].
- Anemia aggravates many obstetric complications like pre-Eclampsia and Antepartum haemorrhage.
- The labour accidents like haemorrhage or shock, is rendered more serious by anemia especially in pregnant women with moderate and severe anemia[32].
- During delivery, the risk of uterine inertia is very high and there is a high risk of postpartum haemorrhage.
- The anemic pregnant women will exhaust more easily than non-anemic women during labour.
- Anemia increases the risk of puerperal sepsis and it also aggravates puerperal sepsis.
- Wound healing will be very slow. Anemia leads to sub-involution of the uterus and lactation failure.

Effects of anemia on the fetus

Even though the fetus functions like a parasite in situations like iron-deficiency, it also suffers from the adverse effects of maternal iron-deficiency .

The risk of premature delivery is increased to two to four times, when the maternal hemoglobin level falls from 10g/dl to 8g/dl[3,7].

Anemia is associated with restriction of growth in the fetus, that according to Barker and associates (1990) may lead to adult cardiovascular diseases[33].

A U – shaped relationship is obtained between the maternal hemoglobin levels and the maturity and the birth weight of the babies i.e. there is a poor perinatal outcome both in very high and very low maternal hemoglobin levels. This is because increased hemoglobin concentration leads to increased viscosity of the blood which will cause clogging of blood and decreased flow in placenta. Whereas, anemia reduces the oxygen-carrying capacity of the blood which leads to poor placental oxygenation[34].

Effects of maternal anemia on iron stores of the fetus are variable. Usually the fetus extracts the iron required for it from the mother. But when the mother herself is depleted of iron stores, the fetus doesn't get adequate iron stores and the neonate is at six –fold increased risk of anemia in infancy[7].

Iron -deficiency-anemia is also associated with increased size of the placenta, which apparently helps the fetus to extract more oxygen to compensate for maternal anemia. However, the placenta is usually under-perfused, and the new theories nowadays point out that these placental alterations are predictors of adult hypertension[35].

Majority of the studies point out the effects of iron deficiency anemia. Other causes of anemia in pregnancy also exert their effects in the fetus. Folate deficiency increases the risk of abortion, abruptio-placenta leading to antepartum haemorrhage, pregnancy induced hypertension and congenital malformations. There is a two fold increased risk of pre-term births and a ten fold increased risk of low birth weight.

Types of Anemia

The following are the different types of anemia associated with pregnancy.

- Iron deficiency anemia
- Megaloblastic anemia
- Aplastic anemia
- Hemoglobinopathies
- Hemolytic anemia
- Secondary causes

(e.g. repeated bleeding, chronic infection, Hodgkin’s disease)

Iron-deficiency-anemia is the commonest type and depending upon the socio-economic status, it may be found in up to 50% to 90% of all pregnancies. Many factors like multiparity, previous menorrhagia, short inter-pregnancy interval, previous abortions and malnutrition contribute to iron deficiency anemia in pregnancy. The importance of chronic infections in the etiology of iron-deficiency-anemia must not be over-looked. Some infections like urinary infections may present as refractory anemia. Hence, appropriate antibacterial therapy is necessary before the administration of hematinics.

Iron Metabolism

The concentration of iron in women is approximately 40mg/kg. This is the result of a balance between the iron losses and iron absorption. In females the most important cause of iron loss is the menstrual loss and parturition.

Absorption of iron depends on the amount of stored iron and the activity of the hematopoietic system. Absorption of iron is increased when the iron stores are low and the hematopoietic system is active and it is decreased when there is good iron stores and decreased hematopoiesis.

Most of the iron in the body is stored in erythrocytes as hemoglobin and in the muscle as myoglobin. A small amount of iron is attached to the transport protein transferrin, but most of the body iron is stored in the bone marrow and liver, attached to ferritin.

Iron Absorption

Iron is absorbed in the brush border of the intestine in the second part of the duodenum by an unknown mechanism. Once internalized, iron is transported in to the plasma or it may be stored in the intestinal cells itself to be lost later when these cells are exfoliated. There is a continuous flow of the iron from the intestinal cells to the transferrin to ferritin to the erythrocytes and from the erythrocytes through the monocyte-macrophage system back to tranferrin and to the ferritin.

Iron Transport

Iron is transported in the plasma and extra-cellular fluid through the transport protein,called transferrin. Transferrin is a glycoprotein which contains two lobes. Each lobe is capable of binding an atom of iron. The protein without iron is called as apotransferrin. When the apoprotein binds one iron atom, it is called as monoferric transferrin and when it binds two iron atoms, it is called as diferric transferrin. The saturation of transferrin by iron atoms represents the percentage of iron-binding sites occupied by iron atoms, which is an important index of iron-deficiency.

Transferrin-bound-iron enters the cells by attaching to the specific transferrin receptors . These transferrin receptors are located on the surface of the cells. These receptors have increased affinity for diferric transferrin than the monomeric transferrin. This iron-transferrin complex moves inside of the cell within an endosome. Then the iron is released inside the cells and it is taken by a divalent metal transporter ,which carries the iron through the endosomic membrane to be incorporated into iron –containing proteins or to be stored as ferritin.

Iron storage

Ferritin is the storage form of iron. It is a spherical protein shell that can store as many as 4500 atoms of iron. Most of the ferritin is stored in the macrophages and hepatocytes. Empty protein shell without iron is called as apoferritin.

Iron Release

Iron is released through the destruction of erythrocytes in the bone-marrow, liver and spleen by some specialized macrophages. They recognize old erythrocytes and phagocytose them. They destroy the membrane of erythrocytes and liberate their hemoglobin. Hemoglobin is rapidly metabolised into the heme.

Heme Catabolism

Heme is catabolised into biliverdin and then into bilirubin by some enzymes and the released iron is incorporated into ferritin or transported back into the plasma.

Iron Requirements During Pregnancy

Iron deficiency accounts for approximately eighty percent of all anemias of pregnancy. The reasons for this predominance are:

1. The suboptimal content of iron in the Indian diet
2. The insufficient stores of iron in all the women in the reproductive age group.
3. Poor absorption of iron as well as its bio-availability.

The daily requirement of iron for an adult is 2 mg. An average Indian diet provides 5 to 15 mg of iron per day. Among this only one-tenth is absorbed. (0.5-1.5 mg). This amount of iron is enough to compensate for the daily as well as the menstrual losses for an adult female, but it is not adequate for the women to build up a large iron stores. Consequently many Indian women enters pregnancy with minimal or no iron stores and the minimal stores are also rapidly exhausted due to the increased demands of pregnancy. To fulfill the iron requirements, a pregnant women should definitely take iron supplements without which she will be deficient in iron stores[36].

Iron Requirements

Maternal requirements are 800 mg/day, of which 300mg is for the fetus and the placenta and the remaining 500mg for the expanding plasma volume. As the placental and fetal requirements are obligatory, much of the dietary intake is diverted to the placenta and fetus even if the mother is iron deficient. Another 200mg of iron is shed through the gut, urine and the shedding of the skin.

Even in western countries,this total requirement of 1000mg cannot be met with the iron stores.Almost all of this iron is used in the second and third trimester of the pregnancy. Therefore, the requirements of iron during pregnancy increases from 0.8mg in the first trimester to 6-7mg/day in the last half of pregnancy. For this much of iron to be absorbed a pregnant women must take 60 to 70 mg of iron per day, which is practically impossible even with iron rich foods in the high socio-economic group. Thus the dietary iron combined with available stores in the body which is mobilized for the increased requirements of pregnancy is insufficient to meet the pregnancy demands.

Therefore, routine supplementation of iron is universally recommended even in non-anemic pregnant women[36].

Clinical and Laboratory Assessment

In pregnant women, suffering from iron-deficiency anemia, the iron stores become depleted in the initial stages to meet the increasing needs of pregnancy. Once the iron stores become depleted, the saturation of transferrin molecules with iron becomes less than 15% and erythropoeisis is impaired, which results in microcytosis and hypochromia. In the last stage, the production of red blood cells by the bone marrow decreases.

Table: 2[37,38]

STAGES OF IRON DEFICIENCY ANEMIA

Depletion of iron stores

- Serum Ferritin < 20 ng/ml
- Normal hemoglobin/hematocrit
- Normal indices of RBC

Iron-deficient hematopoiesis

- Serum Ferritin <20ng/ml
- Transferrin saturation <20%
- Serum iron<60ug/dl
- TIBC >400ug/dl
- Erythrocyte zinc protoporphrin concentration >70umol/mol haem

Frank iron-deficiency anemia

- Serum Ferritin <20ng/ml
- MCV <80 mm^3;MCH<26 pg/cell;RDW>14.5%
- Transferrin saturation <20%
- Serum iron<60ug/dl
- Hemoglobin <11g/dl;hematocrit <28%
- TIBC >400ug/dl
- Erythrocyte zinc protoporphrin concentration >70umol/mol haem

Thus, iron deficiency anemia is divided into three stages[39]

- Depletion of stores of iron
- Iron deficient erythropoiesis
- Frank iron-deficiency anemia

Depletion of iron stores does not have any overt manifestations. It usually occurs in the first trimester of pregnancy. Serum Ferritin concentration is used to assess the status of iron stores in this stage. The normal range of ferritin is 50-155 ng/ml, and any value below 20ng/ml is indicative of iron stores. A serum ferritin less than 12ng/ml indicates complete depletion of iron stores. A normal serum concentration of ferrtin rules out iron-deficiency.

Routine estimation of serum ferritin in all the pregnant women is practically impossible. Some investigators believe that routine supplementation of iron to all pregnant women, with the assumption that their iron stores are low costs less than screening all pregnant women with serum ferritin assay. But serum ferritin has certain limitations. It cannot differentiate between the iron-deficiency anemia and anemia due to chronic disorders. Another limitation is, ferritin being an acute phase reactant, its concentration is increased in conditions associated with infection, inflammation and malignancy.

Iron-deficient hematopoiesis can be diagnosed by a battery of tests. In this stage , the peripheral blood picture shows the presence of normocytic cells. The parameters used are, percentage of transferrin saturation , erythrocyte zinc protoporphyrin concentration (ZPP), total iron binding capacity (TIBC) and soluble transferrin receptor concentration assay[40,41].

The normal values of all these parameters[39]

Transferrin saturation	20-50%
TIBC	325-400ug/dl
Serum iron	60-120 ug/dl
ZPP	40-70 umol/mol haem

Transferrin saturation is calculated by the ratio of serum iron/TIBC multiplied by 100.

ZPP represents the substrate used for red blood cell synthesis. Its level rises when there is a deficient erythropoiesis.

Serum transferrin receptor (Tfr), measured by ELISA, is a new method for assessing the cellular iron status[42]. It is very useful in iron deficiency in pregnant women, as it is the only test which signifies the iron deficit between the stage of storage iron depletion and the frank iron deficiency anemia. There is very minimal or no change in the Tfr concentration in the stage of storage iron depletion. But it rises proportionately to the magnitude of iron deficiency, as soon as cellular iron deficiency is established and it precedes the reduction of MCV and the rise of ZPP. Anemia occurs after the functional compartment iron is depleted. In absolute values, this coincides with the Tfr value of 8.8mg/ml as compared to the baseline average of 5.3mg/ml.

Table.3

Categories of iron deficiency anemia:

The categories of iron –deficiency anemia[37]:

	Hemoglobin	**Serum ferritin**
Iron deficient, but not anemic	>11g/dl	<12ng/ml
Iron deficiency anemia	<11g/dl	<12ng/ml
Anemia not due to iron deficiency	<11g/dl	>12ng/ml

Iron deficiency anemia usually represents the tip of the iceberg. In this stage, the hemoglobin and hematocrit values fall and the MCV, MCH, MCHC levels also falls in addition to the other changes mentioned in the previous stages. There is anisocytosis and polychromasia. The red cell distribution width is increased. The bone marrow is normoblastic.

Strategies for Correcting Iron Deficiency Anemia:

There are three strategies for correcting iron deficiency in pregnant women[43]:

They are

- combination of diet modification and health education and diversification which will improve the bioavailability of iron.
- routine supplementation of iron
- fortification of foods with iron

Although there are many recommendations on dietary modifications, it is practically impossible to take the required amount of iron through the diet and taking foods with high bio-availability of iron (eg.meat) is expensive[43].

Iron Supplementation:

Iron supplementation is the most commonly used strategy among all the three. It is the only cost effective method. But the logistics of distribution and the poor compliance are the limitations.

For oral supplementation, ferrous sulphate and ferrous fumarate are the preferred iron salts in our country because of their high low cost and high bioavailability. Standard therapy used in our country is 300 mg of ferrous sulphate which provides 60 mg of elemental iron three to four times a day.

Absorption is enhanced in empty stomach but the problem is nausea and gastritis. So when such a problem arises, it is better to take the tablet either in between the meals or along with the food, even though its absorption is decreased to two third when it is taken with the food[44].

Supplementation of iron can be given every few days. By this, the fractional iron absorption can be increased [45]. Some of the studies conducted by WHO, are of the view that iron supplementation can be given weekly once to the women of child bearing age groups in South-East- Asia and thereby, the iron nutriture can be improved and iron deficiency anemia can be decreased.

Diet Modification:

Diet modification includes strategies to improve the availability of iron-rich foods, to improve the access of households to such foods and to improve the dietary habits with respect to these foods[46].

Iron-rich foods include, animal foods like meat , fish, poultry and liver and non-animal foods like legumes, pulses, green leafy vegetables, nuts, oilseeds, dried fruits and jaggery. In general, animal foods have good absorption and better bioavailability than the vegetable foods[46].

Absorption of iron is increased by enhancers in the diet like ascorbic acid present in citrus fruits, cabbage, cauli-flower, tubers, germinated foods. It is decreased by the inhibitors like phytates present in the cereals, legumes, nuts and seeds, tannins present in the tea, coffee, phosphate in egg yolk and oxalates in the vegetables. So simple measures like taking fresh citrus fruits along with the food, avoiding the dairy products and other inhibitors along with the meals and separating the tea-time by atleast 2 hours from the meals improve the bioavailability of iron[46].

Iron fortification

Iron fortification is a simple and cost-effective approach in developing countries like India[46,47]. But the problem with fortification of iron is, unlike vitamin A in cooking oil and the iodised salt , iron compounds used for fortification are water soluble and they often react with the food compounds causing colour changes and flavor changes or fat oxidation or both[48]. So low soluble compounds are preferred ,even though they have poor bioavailability . Fortification is more similar to the physiologic environment than the supplementation and it is a safe intervention.

Recommended doses of iron and folic acid

National Nutrition and Anemia Control Program (NNACP) recommends 100 tablets of iron (300 mg of ferrous sulphate containing 100 mg of elemental iron along with 500ug of folic acid) to all pregnant women starting after the first trimester of pregnancy[49].

Effects of maternal iron-deficiency on the fetus:

The effects of maternal iron-deficiency on the fetus may vary. Multiple studies are conducted in this regard to find out the effects. Some studies are pointing out that, the fetus extracts the iron it needs from the maternal serum iron and so if the stores are absent in the mother itself as a result of iron deficiency, the fetus cannot take the required iron and will have inadequate iron stores and land up in anemia in infancy itself.

Some studies conducted later, infer that the fetal stores are independent of maternal level. The fetus acts like a parasite and it extracts the amount needed for it from the mother and it can even induce iron-deficiency in the mother.

Similarly some studies point out that there is fetal growth restriction in iron-deficiency anemia and babies will have low birth weight. But there are some studies contradicting this and they say that heavy babies extract more iron from the mother than smaller babies and so induce iron-deficiency in the mother.

Many studies are conducted nowadays, to find the iron content of breast-milk in anemic and non-anemic mothers .

Influence of cord clamping on the iron stores of the baby

If after labour, the neonate is placed at or below the level of the vaginal introitus of the mother for three minutes and the feto –placental circulation is not immediately occluded by cord clamping, an average of eighty ml of blood may be transferred to the baby from the placenta.(Yao and Lind 1974)[50]. This provides about 50 mg of iron to the fetus which reduces the frequency of anemia later in the infancy.

The hazards with this are accelerated destruction of red blood cells like maternal alloimmunisation resulting in hyperbilirubinemia. Although there is an increased risk of overloading the child with this blood in pre-term and growth retarded infants, the addition of placental blood to the otherwise normal neonate did not cause any significant abnormality[50].

MATERIALS AND METHODS

STUDY DESIGN

Cross-sectional study

PARTICIPANTS SELECTION

Inclusion criteria

The study was conducted on 75 pregnant women either primi or second gravida delivering singleton live births at term gestation (37-41 weeks) in Tirunelveli Medical College Hospital.The pregnant women were selected consecutively.

Exclusion criteria

- Premature rupture of membranes(PROM>24 hrs)
- Fever
- Foul-smelling liquor
- Ante-partum haemorrhage (APH)
- Pregnancy Induced Hypertension (PIH)
- Eclampsia
- Gestational Diabetes-mellitus or Diabetes complicating pregnancy
- Liver disorders
- Kidney disorders
- Women with other systemic illness
- Women who have received blood transfusions.

The participants were selected based on this inclusion and exclusion criteria. Of the 75 participants, 14 had anemia (Hb<11g/dl) with normal iron stores (SF>55ng/ml) pointing towards other causes of anemia and they were not included in the study as the study is on iron deficient anemic mothers.

The subjects (n=61) were divided into 4 groups:

Group 1: Hemoglobin $\leq$6.9g/dl

Group 2: Hemoglobin 7-9.9g/dl

Group 3: Hemoglobin 10-10.9g/dl

Group 4: Hemoglobin $\geq$11g/dl.

Gestational age of the pregnancy was calculated from the first day of the last menstrual period. The calculated gestational age was confirmed by the New Ballard score. Informed consent was taken from the pregnant women after explaining the study protocol and the procedures. The study protocol was approved by the ethical committee of the institute.

Collection of samples and Laboratory Analysis

Maternal blood samples were collected in iron-free polyethylene tubes from the mother's ante-cubital vein during the first stage of labour . Cord blood samples were also collected in iron-free polyethylene tubes from the placental end of the umbilical cord without milking just after the second stage of the labour. From the collected samples hemoglobin,RBC indices, serum iron and serum ferritin were estimated .Hemoglobin and RBC indices are calculated using automated analyser, Serum iron using calorimetry and Serum ferritin using immunohistochemistry.

Statistical Analysis

The statistical analysis was done using Chi-Square test to find the association between the parity, educational status of the father and mother, occupational status with the severity of anemia. Differences in mean parameters between the pregnant women and their newborns in the four groups were determined using the analysis of variance. Pearson's correlation coefficient was used for the correlation analysis. A p-value of <0.05 was considered to be significant for all the tests.

OBSERVATIONS AND RESULTS

61 pregnant women and their newborns were enrolled in the study to determine the relationship between them with regard to their iron status. Only primi and second gravida were included in the study.

These 61 pregnant women were divided into 4 groups based on their hemoglobin levels done by automated analyser.

Group 1: Hemoglobin level≤6.9 gm/dl

Group 2: Hemoglobin level 7g/dl -9.9g/dl

Group 3: Hemoglobin level 10g/dl -10.9g/dl

Group 4: Hemoglobin level ≥ 11g/dl

No of pregnant women in each group:

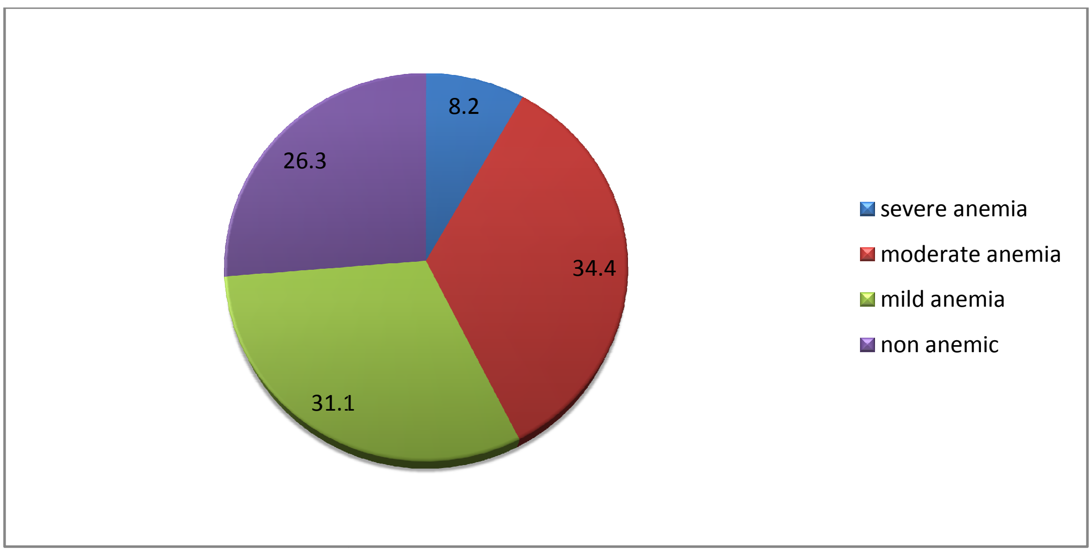
- Group 1 contained 5 pregnant women and they constituted 8.2% of the sample size.
- Group 2 contained 21 pregnant women and they constituted 34.4% of the sample size.
- Group 3 contained 19 pregnant women and they constituted 31.1% of the sample size.
- Group 4 contained 16 pregnant women and they constituted 26.3% of the sample size.

Table. 4

Classication of pregnant women into 4 groups according to the hemoglobin level

	Hemoglobin g/dl	**n**	**percentage**
Group 1	≤ 6.9	5	8.2
Group 2	7 -9.9	21	34.4
Group 3	10-10.9	19	31.1
Group 4	≥ 11	16	26.3

Fig : 3



This data shows that 78.7 % (59 out of 75) of pregnant women studied were anemic.

Table.5

Parity

	Frequency	Percent	Valid Percent	Cumulative Percent
PRIMI	32	52.5	52.5	52.5
NON PRIMI	26	42.6	42.6	95.1
G2A1	3	4.9	4.9	100.0

Fig.4

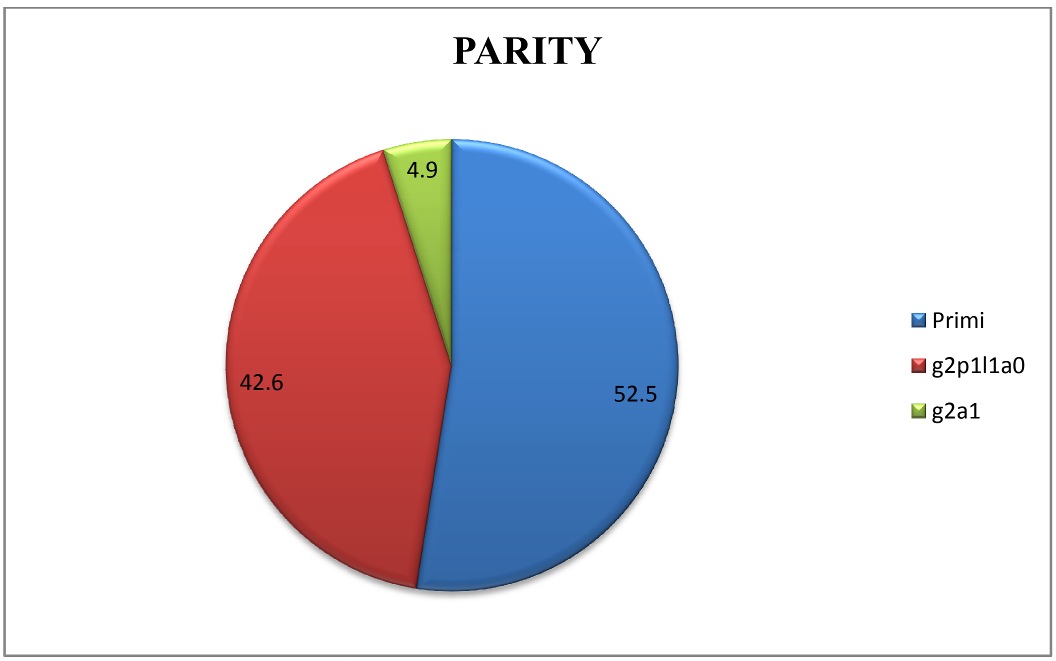


Table.6

Parity Distribution of the Participants

PARITY		**MOTHER –HEMOGLOBIN CATEGORY**			
		≤6.9 g/dl	**7-9.9 g/dl**	**10-10.9 g/dl**	**≥11 g/dl**
PRIMI	COUNT	3	10	10	9
	PERCENTAGE (within parity)	9.4	31.3	31.3	28
G2P1L1	COUNT	2	10	8	6
	PERCENTAGE (within parity)	7.7	38.5	30.8	23.1
G2A1	COUNT	0	1	1	1
	PERCENTAGE (within parity)	0	33.3	33.3	33.3

Table.7

Chi-Square Tests Showing the Significance of Parity

	value	df	P value
Pearson Chi-Square	0.732	6	0.994
Likelihood Ratio	0.973	6	0.987
No. of valid cases	61		

Only primi and second gravida in the age group of 20 to 32 were selected to make the different study groups comparable with respect to age and parity. In the present study group, 52.5% were primi and they were the major group. Rest of the women were second gravida and they constitute 47.5%. In the group of second gravida women with previous live births were 42.6% and the women with previous abortions were 4.9%.

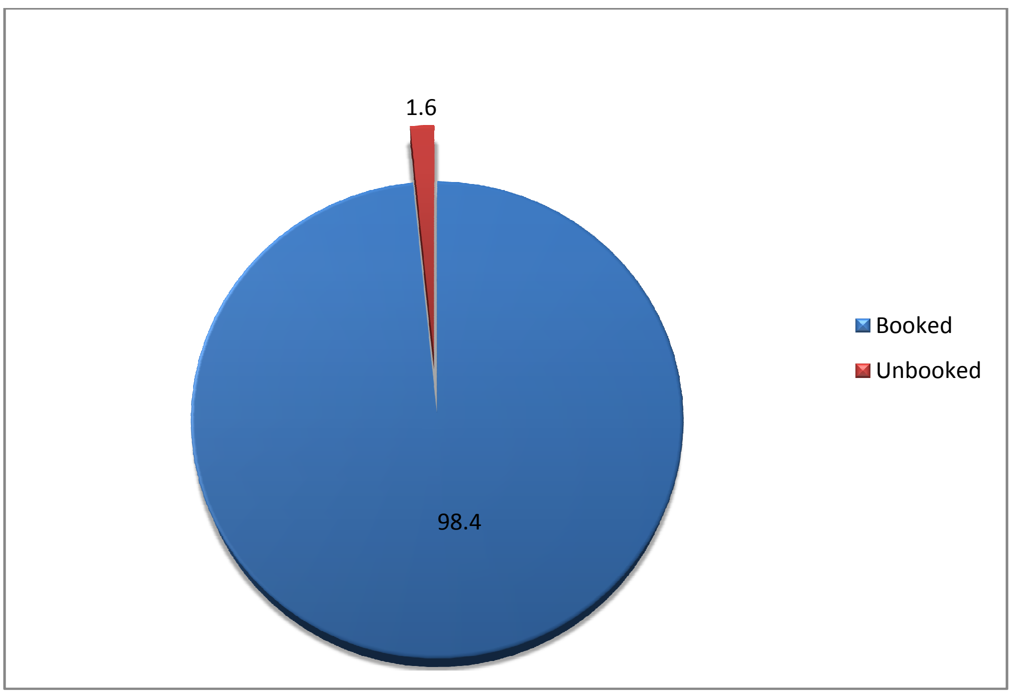
From the Chi –square table for parity, it is obvious that parity does not carry any significance between the groups.($p>0.05$). The four groups are comparable with respect to the parity.

Table.8

No of booked and unbooked cases

	Frequency	Percent	Valid Percent	Cumulative Percent
Booked	60	98.4	98.4	98.4
Unbooked	1	1.6	1.6	100.0

Figure.5



Out of the 61 pregnant women studied, 60 had atleast 3 antenatal visits and they are booked cases. Only one women was unbooked. Another surprising data in my study is that all women had taken iron tablets including the unbooked case. She was given iron tablets in the last trimester. This shows a good health care system in our state. Even though the number of tablets taken by these women may vary, it is very appreciable fact that all were provided with iron tablets. But all the pregnant women in my study, except a very few had not taken the iron tablets in the prescribed doses.

The various reasons offered for this by many of them were impalatability, gastrointestinal intolerance such as nausea and vomiting, giddiness, constipation and diarrhea. A very few of them had a false belief that iron intake will make the baby heavier, which will result in caesarean section for them.

24 women had received iron injections. Some of them were admitted for safe confinement. Many of them were referred to our hospital for anemia and for various other causes, as it is a tertiary health centre.

Table.8

Educational status of the mother

	Frequency	Percent	Valid Percent	Cumulative Percent
Nil	7	11.5	11.5	11.5
Primary School	15	24.6	24.6	36.1
Middle School	8	13.1	13.1	49.2
High school	15	24.6	24.6	73.8
Higher Sec School	8	13.1	13.1	86.9
Degree	8	13.1	13.1	100

Figure. 6

Bar chart showing the educational status of the mother

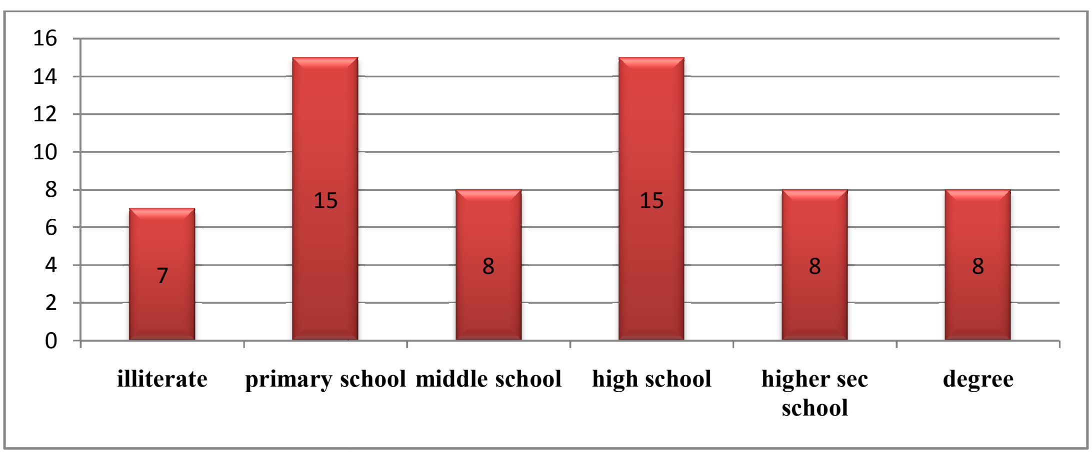


Table.10

Education of the mothers in the four groups

Education of the Mother		**Mother-Hemoglobin Category**			
		≤6.9 g/dl	**7-9.9 g/dl**	**10-10.9 g/dl**	**≥11 g/dl**
Nil	Count	1	2	2	2
	%	14.3	28.6	28.6	28.6
Primary School	Count	1	4	5	5
	%	6.7	26.7	33.3	33.3
Middle School	Count	1	5	1	1
	%	12.5	62.5	12.5	12.5
High school	Count	2	6	5	2
	%	13.3	40	33.3	13.3
Higher Sec School	Count	0	2	3	3
	%	0	25	37.5	37.5
Degree	Count	0	2	3	3
	%	0	25	37.5	37.5

Table.11

Chi-square tests showing the significance of Education of mothers in the four groups:

	value	**df**	**P value**
Pearson Chi-Square	8.812	15	0.887
Likelihood Ratio	10.156	15	0.810
No. of valid cases	61		

Of the 61 pregnant women, 7 of them were not able to read and write and 8 of them were degree holders. 15 had education upto the primary school level, 8 upto the middle school level, 15 upto the high school level and 8 upto the higher secondary level.

Education of the mothers do not have significant difference between the four groups. ($p>0.05$). This shows that both the literates and illiterates pregnant women suffered from anemia.

Table. 12

Educational status of Father

	Frequency	Percent	Valid Percent	Cumulative Percent
Nil	9	14.8	14.8	14.8
Primary School	8	13.1	13.1	27.9
Middle School	11	18.0	18.0	45.9
High school	15	24.6	24.6	70.5
Higher Sec School	13	21.3	21.3	91.8
Degree	5	8.2	8.2	100.0

Figure .7

Bar chart showing the educational status of the father

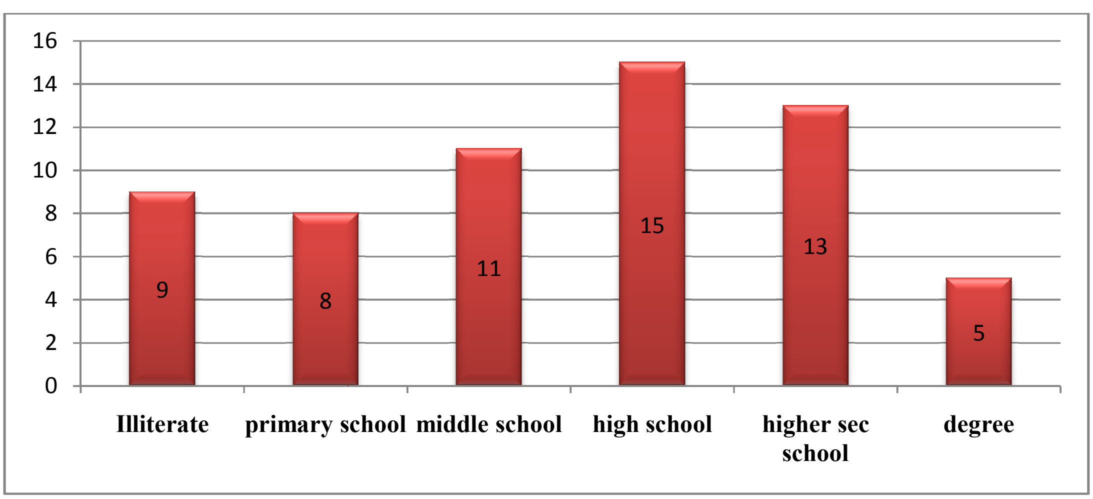


Table.13

Occupational Status of the Mother

	Frequency	Percent	Valid Percent	Cumulative Percent
Working	23	37.7	37.7	37.7
Not working	38	62.3	62.3	100.0

Figure.8

Pie Chart Showing The Occupational Status of Mother

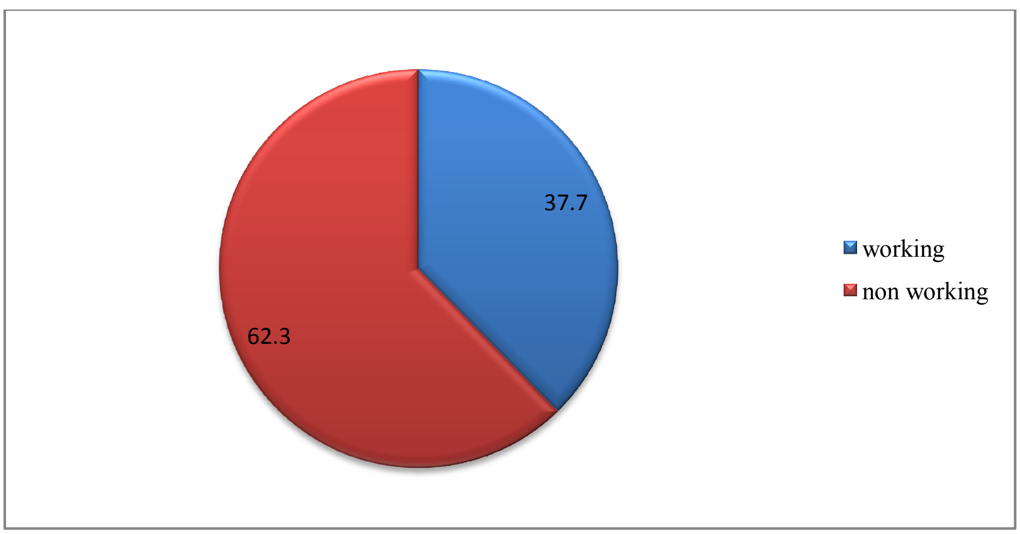


Table. 14

Occupational status of the mothers in the four Groups

Occupation status of the Mother		**Mother-Hemoglobin Category**			
		≤6.9 g/dl	**7-9.9 g/dl**	**10-10.9 g/dl**	**≥11 g/dl**
Working	Count	1	7	7	8
	%	4.3	30.4	30.4	34.8
Non-working	Count	4	14	12	8
	%	10.5	36.8	31.6	21.1

Table.15

Chi-square tests showing the significance of occupational status of women in 4 groups:

	Value	**df**	**P value**
Pearson Chi-square	1.874	3	0.599
Likelihood ratio	1.911	3	0.591

Occupational status of the women do not carry any significance among the pregnant women in the four groups.(p>0.05)

Table.16

Admitted for

	Frequency	Percent	Valid Percent	Cumulative Percent
Referral	29	47.5	47.5	47.5
Safe confinement	32	52.5	52.5	100.0
Total	61	100.0	100.0	

Figure. 9

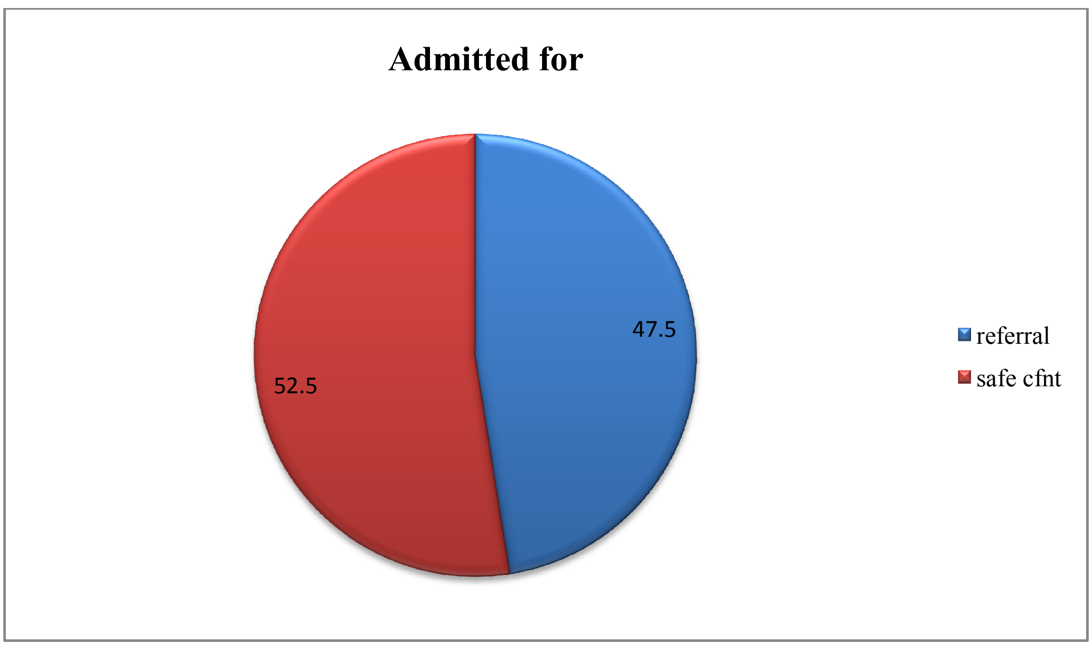


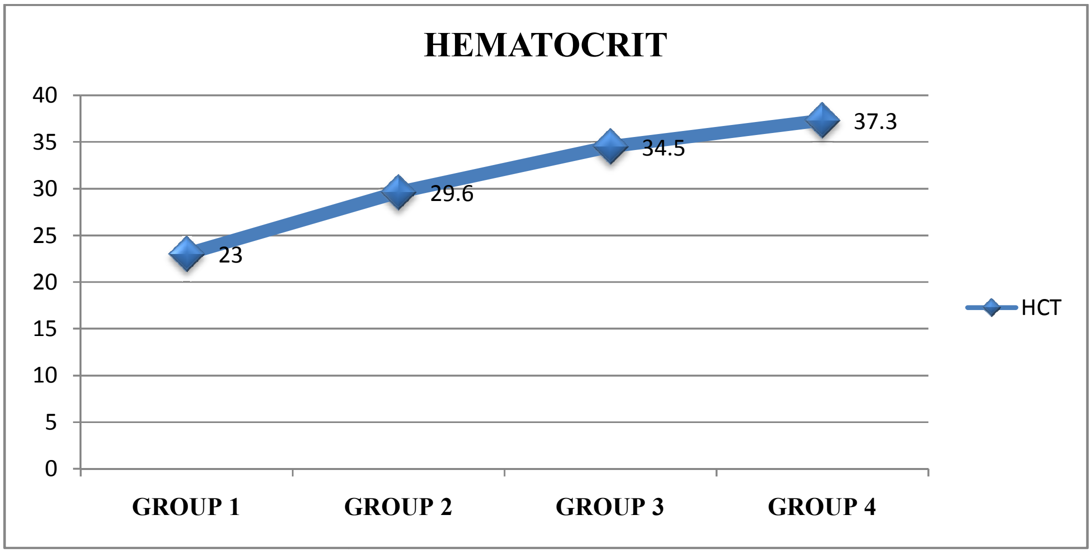
Table.17

RBC indices of the mother

Mother hemoglobin category		HCT	MCV	MCH	MCHC
≤ 6.9 gm%	Mean	23.160	75.880	20.060	27.660
	Std. Deviation	2.1652	8.3016	2.9746	2.4048
7 - 9.9 gm%	Mean	29.648	73.910	22.976	29.624
	Std. Deviation	3.0868	7.1412	4.0307	2.0114
10 - 10.9 gm%	Mean	34.526	82.074	26.800	30.637
	Std. Deviation	1.8351	5.7876	4.2665	1.4025
≥ 11 gm%	Mean	37.363	88.819	29.300	32.287
	Std. Deviation	2.5448	4.9733	2.1824	.9077
Total	Mean	32.659	80.525	25.587	30.477
	Std. Deviation	4.8800	8.6049	4.6616	2.0805

Figure.10

Line diagram showing the Hematocrit values of Mother



The hematocrit values of the mother in the 4 groups shows a linear relationship with the Hemoglobin values of the mother and so a curve like this was obtained.

Figure.11

Line diagram showing the MCV values of the mother

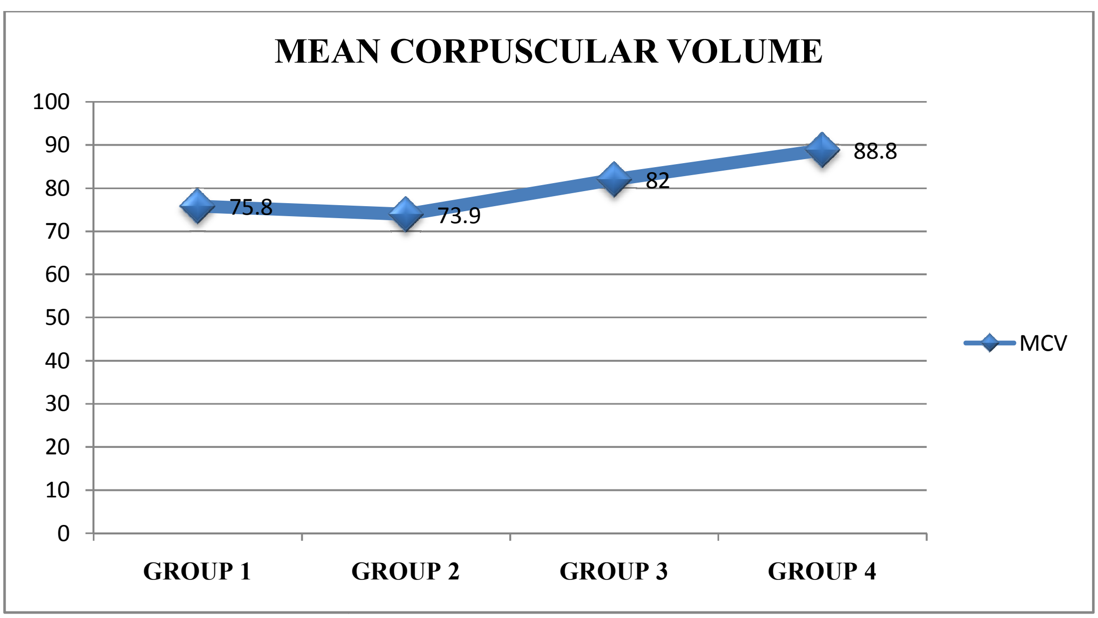


Figure.12

Line diagram showing the MCH values of the Mother

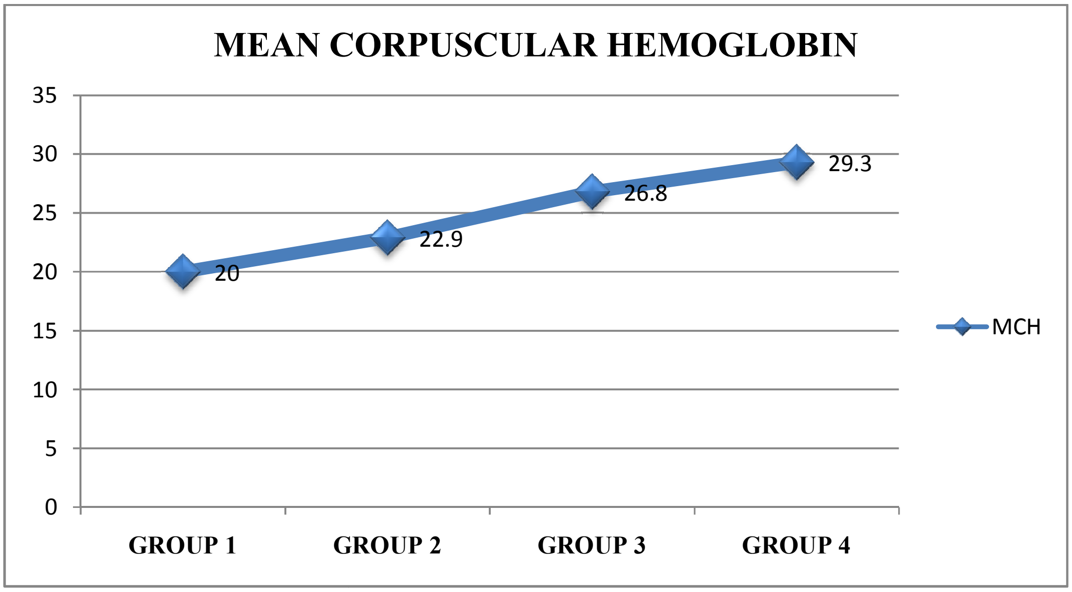
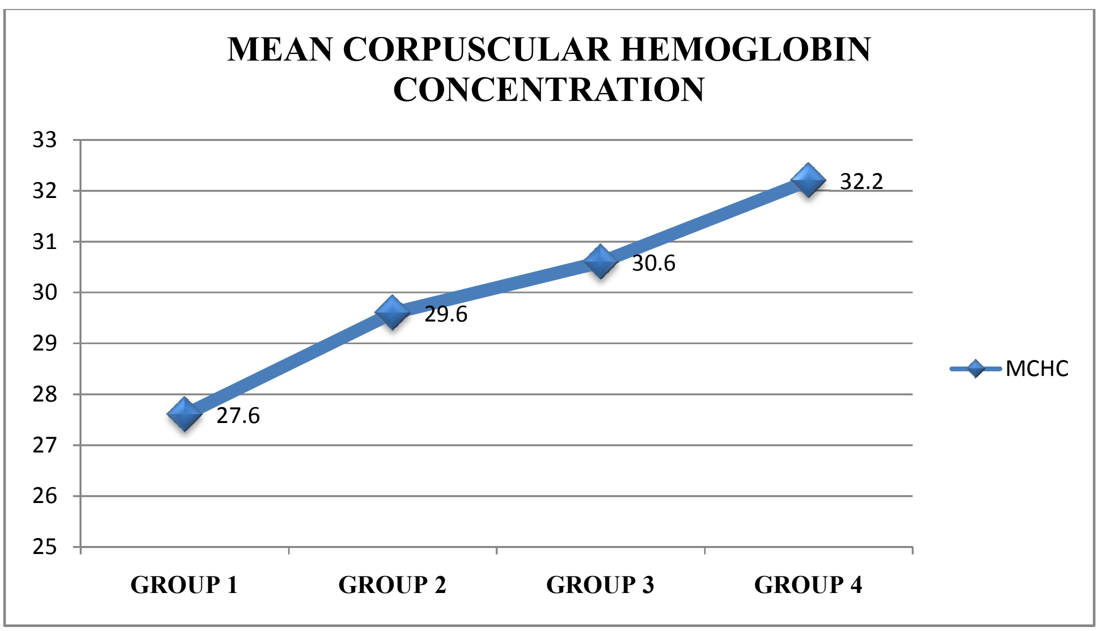


Figure.13

Line diagram showing the MCHC values of the Mother



From all the line diagrams above, it is obvious that there is a linear relationship of all the parameters mentioned above.

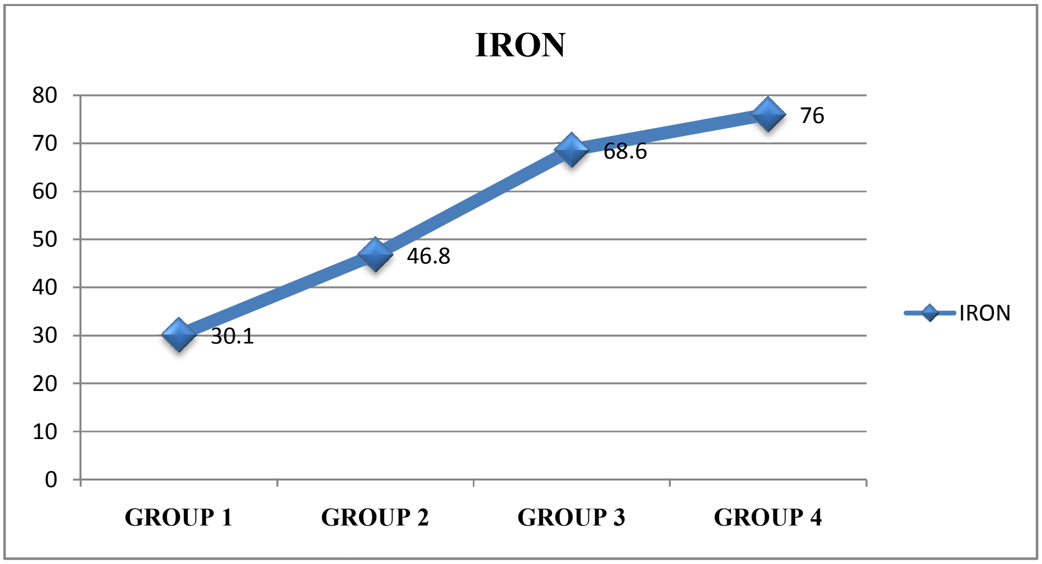
Table.18

Iron and Ferritin Stores of the Mother

Mother hemoglobin category		**IRON**	**FERRITIN**
≤ 6.9 gm%	Mean	30.100	9.040
	Std. Deviation	4.8229	3.0534
7 - 9.9 gm%	Mean	46.824	14.456
	Std. Deviation	9.5380	3.9742
10 - 10.9 gm%	Mean	68.647	24.874
	Std. Deviation	30.4540	13.2769
≥ 11 gm%	Mean	76.038	46.100
	Std. Deviation	25.8380	15.4580
Total	Mean	59.913	25.557
	Std. Deviation	26.5430	17.2354

Figure :14

Line diagram showing the serum iron levels of the Mothers



This line diagram shows the serum iron levels of the mothers in all the 4 groups. Serum iron level which is the circulating form shows a linear relationship with the Hemoglobin levels of the mothers in all the four groups.

Figure :15

Line diagram showing the ferritin levels of the mother

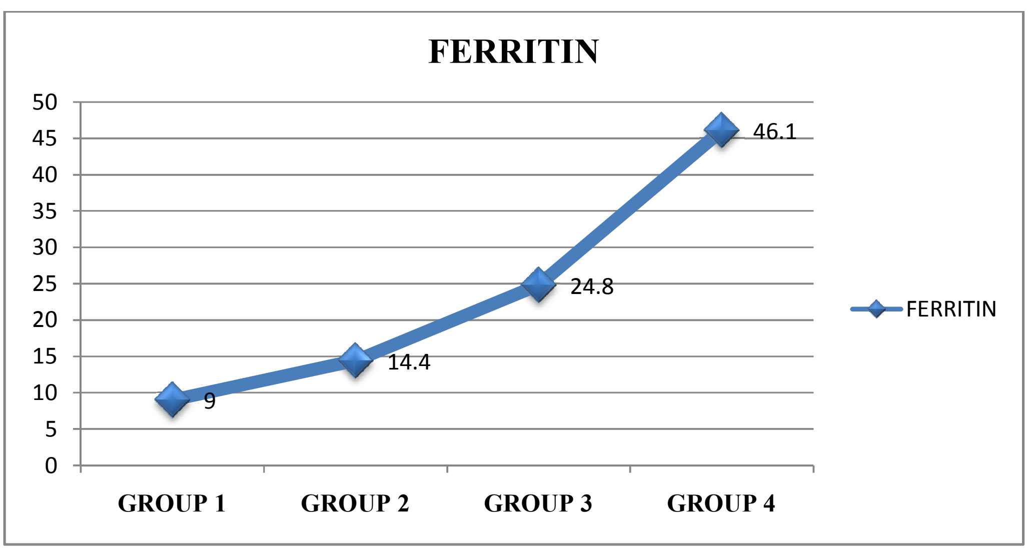


Table.19

Anova table showing the RBC indices and iron stores of the mothers and its significance levels

			Mean Square	F	Sig.
HCT * mother HB category	Between Groups	(Combined)	353.936	54.959	.000
	Within Groups		6.440		
MCV * mother HB category	Between Groups	(Combined)	724.362	18.192	.000
	Within Groups		39.817		
MCH * Mother HB category	Between Groups	(Combined)	181.473	13.621	.000
	Within Groups		13.323		
MCHC * Mother HB category	Between Groups	(Combined)	35.965	13.504	.000
	Within Groups		2.663		
Iron * Mother HB category	Between Groups	(Combined)	4550.476	9.063	.000
	Within Groups		502.114		
Ferritin * Mother HB category	Between Groups	(Combined)	3571.058	28.627	.000
	Within Groups		124.744		

This ANOVA TABLE shows the significance levels of the RBC indices and the iron stores of the mothers with respect to their hemoglobin levels between the four groups. The significance levels is 0.000 ($P<0.05$)in all the categories.This value shows that there is a significant difference in the RBC indices values and the iron stores of the mothers between the 4 groups.

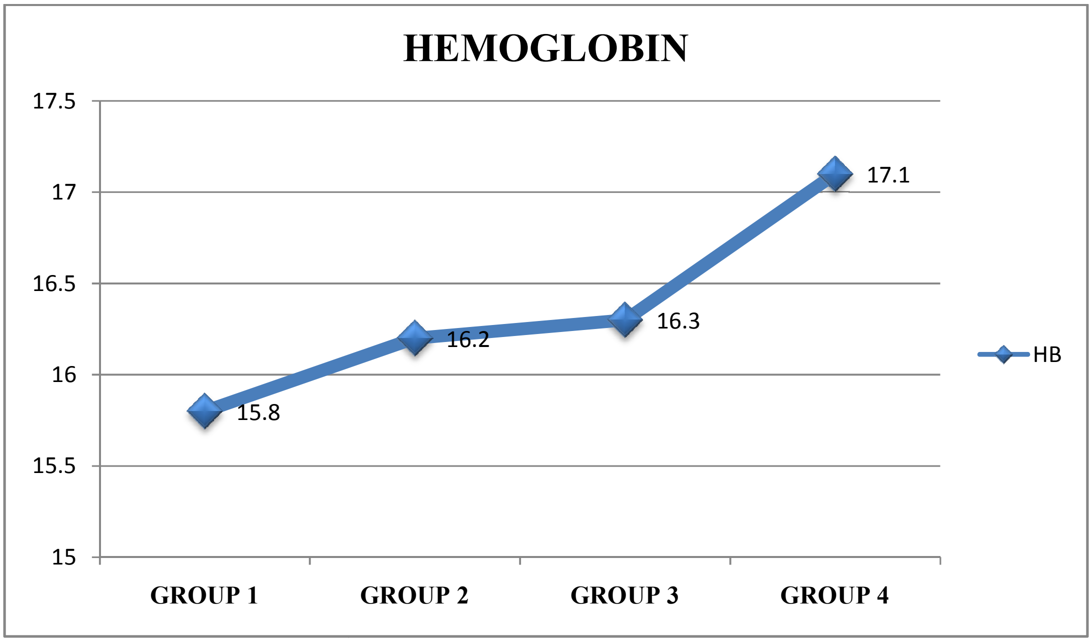
Table. 20

RBC indices of the baby

MOTHER HB CATEGORY		BABY HB	HCT	MCV	MCH	MCHC
≤ 6.9 gm%	Mean	15.840	49.520	107.600	33.920	32.160
	Std. Deviation	1.1371	3.1515	4.8862	2.9828	.4827
7 - 9.9 gm%	Mean	16.286	49.924	109.400	33.790	32.257
	Std. Deviation	1.4506	5.8844	6.0032	2.4845	1.7876
10 - 10.9 gm%	Mean	16.353	50.026	106.474	34.274	32.574
	Std. Deviation	1.0595	2.8757	4.3133	1.7294	1.6210
≥11 gm%	Mean	17.194	53.856	106.200	33.906	32.344
	Std. Deviation	1.8124	6.4920	3.5308	.6718	1.4796
Total	Mean	16.508	50.954	107.502	33.982	32.370
	Std. Deviation	1.4605	5.3182	4.9347	1.9242	1.5613

Figure.16

Hemoglobin values of the baby in all the 4 groups



The line diagram is in rising trend along the four groups. This shows that there is a correlation in hemoglobin values of the baby and the mother.

Figure.17

Line Diagram Showing The Hematocrit Values Of The Baby

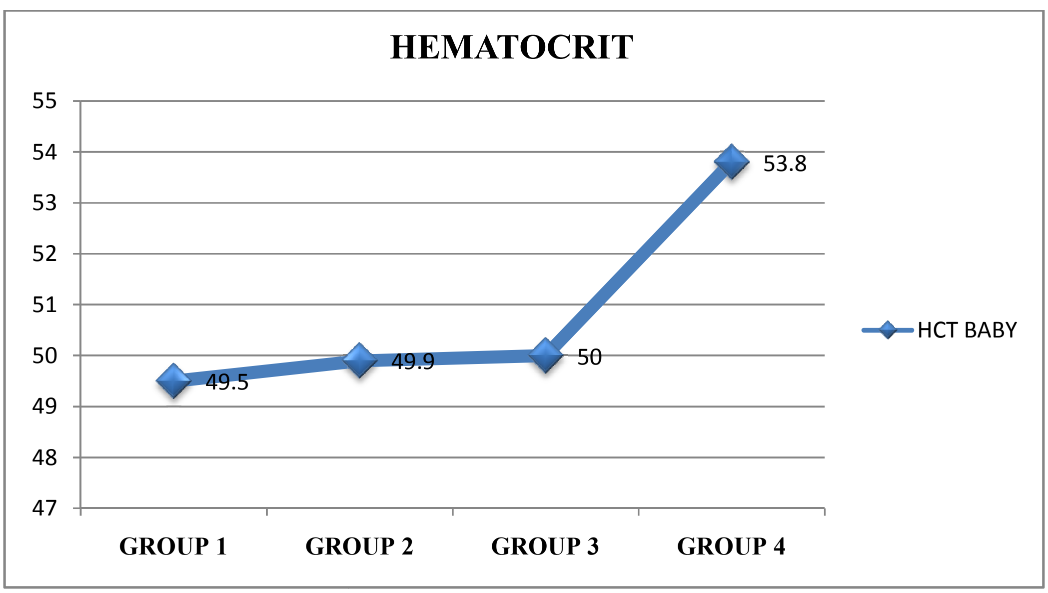
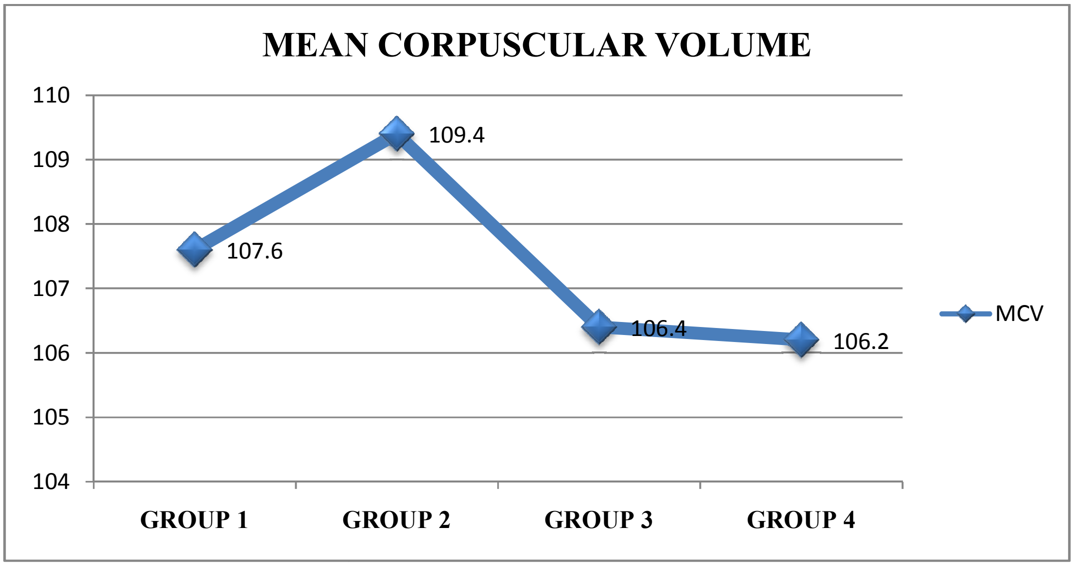


Figure.18

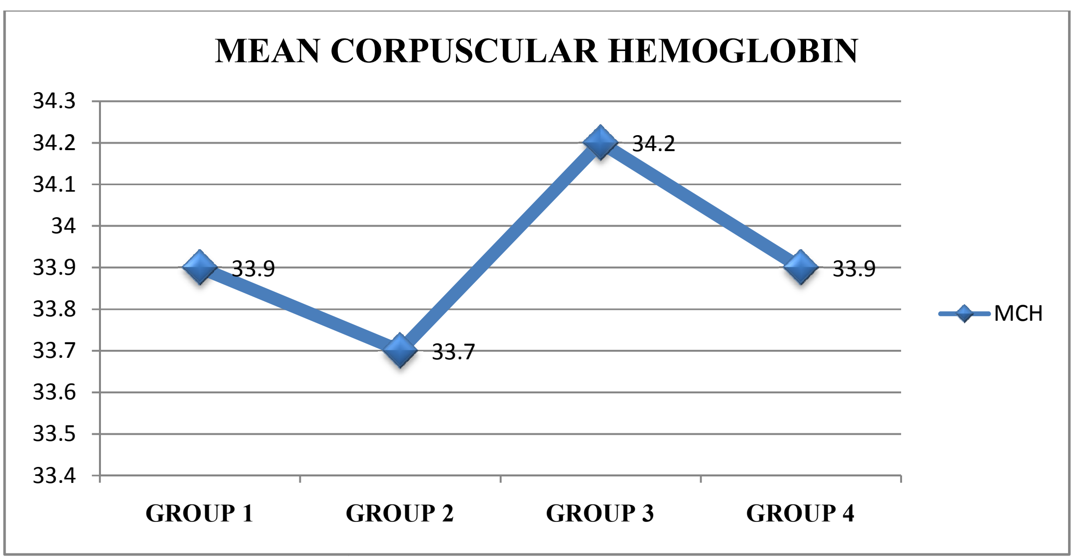
Line diagram showing the MCV values of the baby



This line diagram shows that there is no correlation of the MCV values of the baby with the hemoglobin values of the mother.

Figure.19

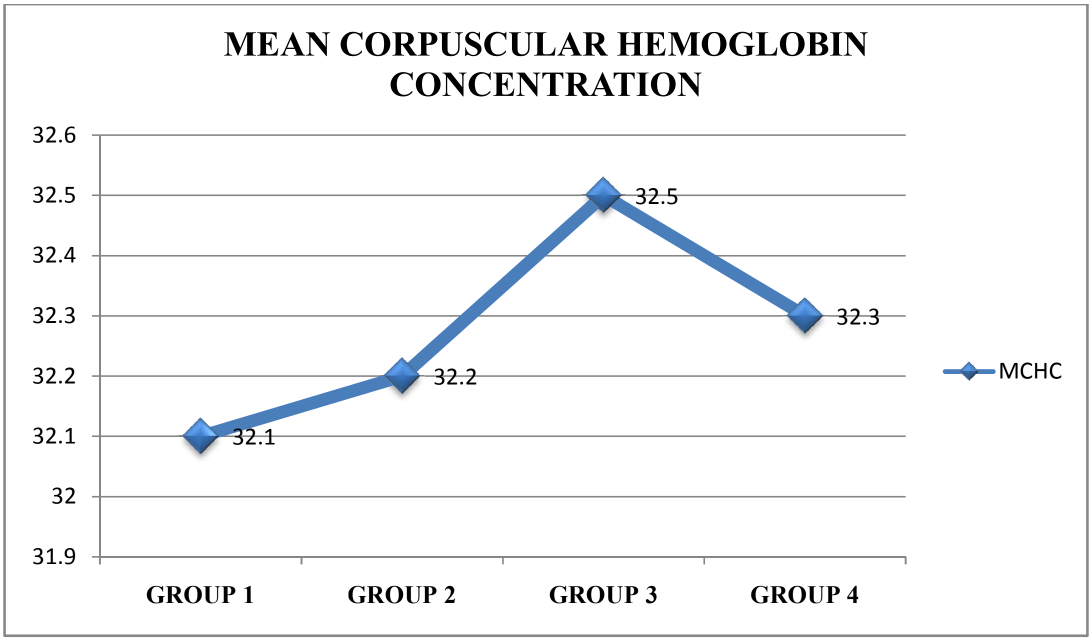
Line diagram showing the MCH values of the baby



This line diagram shows that there is no correlation of the MCH values of the baby with the hemoglobin values of the mother.

Figure.20

Line diagram showing the MCHC values of the baby



This line diagram shows that there is no correlation of the MCHC values of the baby with the hemoglobin values of the mother.

Correlation of the RBC indices of the baby with the maternal Hemoglobin values:

From all the data and diagrams showed above, it is obvious that hemoglobin and hematocrit values of the baby shows correlation with the maternal hemoglobin levels.

The RBC indices of the baby measured (mean corpuscular volume, mean corpuscular hemoglobin, mean corpuscular hemoglobin concentration) shows no correlation (positive or negative) with the maternal hemoglobin levels.

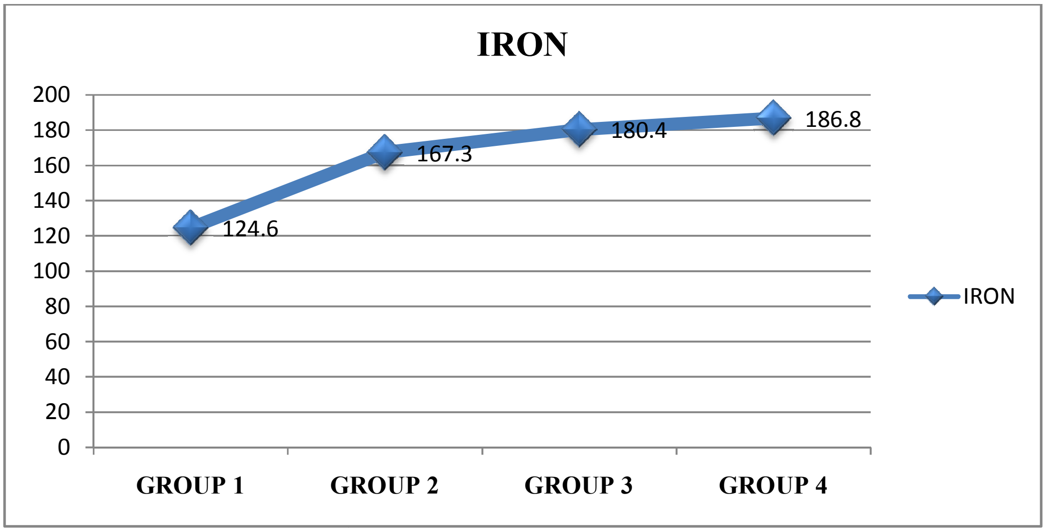
Table. 21

Serum iron and Ferritin values of the baby

Mother hemoglobin category		**Iron**	**Ferritin**
≤ 6.9 gm%	Mean	124.640	52.100
	Std. Deviation	62.5261	13.7971
7 - 9.9 gm%	Mean	167.352	129.759
	Std. Deviation	50.5704	42.3154
10 - 10.9 gm%	Mean	180.453	131.284
	Std. Deviation	50.3678	54.8261
≥ 11 gm%	Mean	186.837	127.563
	Std. Deviation	61.4569	42.4874
Total	Mean	173.043	123.292
	Std. Deviation	55.6157	49.2413

Figure.21

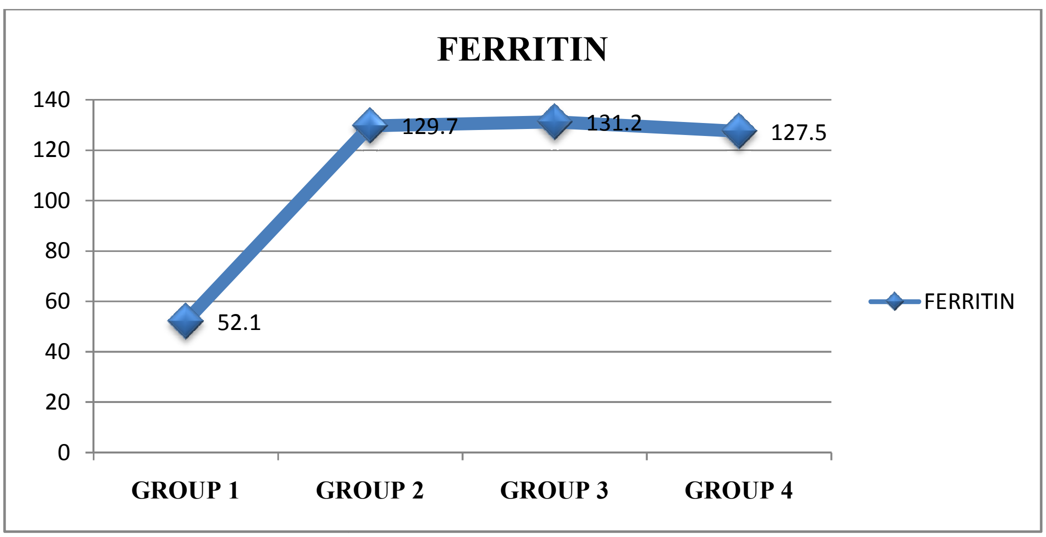
Line diagram showing the serum iron levels of the baby



This line diagram shows that there is correlation the serum iron levels of the baby with the maternal hemoglobin levels. ($p<0.05$)

Figure.22

Line diagram showing the serum Ferrin levels of the baby:



This diagram shows that there is a positive correlation of ferritin values with significance. ($p<0.05$)

Table.22

Anova table showing the RBC indices and its significance

			Mean Square	F	Sig.
Baby HB * mother HB category	Between Groups	(Combined)	3.750	1.831	.152
	Within Groups		2.048		
Hematocrit * mother HB category	Between Groups	(Combined)	61.230	2.306	.086
	Within Groups		26.549		
MCV * mother HB category	Between Groups	(Combined)	40.971	1.745	.168
	Within Groups		23.476		
MCH * mother HB category	Between Groups	(Combined)	.833	.216	.885
	Within Groups		3.854		
MCHC * Mother HB category	Between Groups	(Combined)	.429	.169	.917
	Within Groups		2.544		
Iron * Mother HB category	Between Groups	(Combined)	5494.020	1.852	.148
	Within Groups		2966.739		
Ferritin * Mother HB category	Between Groups	(Combined)	9241.693	4.473	.007
	Within Groups		2065.915		

Correlations

Hemoglobin and Hematocrit values of the baby shows a positive correlation with the maternal hemoglobin values.(Table :23)

RBC indices of the baby (mean corpuscular volume, mean corpuscular hemoglobin, mean corpuscular hemoglobin concentration) doesn't correlate with the maternal hemoglobin levels and there is no significance (p value> 0.05).Among these MCV values shows a negative correlation, but it is not statistically significant (P>0.05). (Table:23). Serum iron and Serum ferritin levels, shows a positive correlation with the maternal hemoglobin levels and it is statistically significant (P<0.05)(TAB:23)

Significant difference between the groups from the Anova table (Table.22)

Even though the hemoglobin and hematocrit values of the baby shows a positive correlation with the maternal hemoglobin levels, there is no significant difference between the groups.

Similarly Serum iron which shows a positive correlation with the maternal hemoglobin levels, does not show a significant difference between the groups.

Serum ferritin alone shows a positive correlation with the maternal hemoglobin levels, as well as a significant difference between the groups. (sig 0.007 which is <0.05 in the ANOVA table 22.)

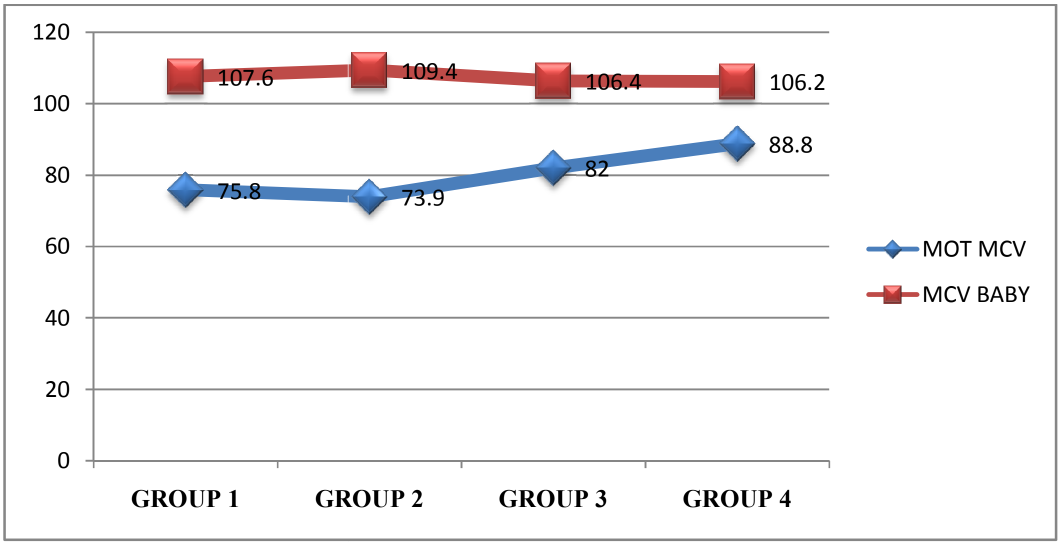
Table.23

Correlations between the maternal and baby values and its significance

		Mot HB	HCT	MCV	MCH	MCHC	Iron	Ferritin
Baby HB	Correlation	.331**	.376**	.284*	.139	.093	.216	.171
	P.Value	.009	.003	.027	.285	.477	.094	.188
HCT	Correlation	.315*	.358**	.333**	.171	.157	.171	.165
	P.Value	.013	.005	.009	.187	.226	.188	.204
MCV	Correlation	-.184	-.152	-.119	-.093	-.028	-.200	-.131
	P.Value	.156	.242	.362	.475	.833	.122	.313
MCH	Correlation	.201	.205	.333**	.295*	.154	.092	.024
	P.Value	.120	.114	.009	.021	.235	.483	.857
MCHC	Correlation	.043	.172	.171	.173	.061	.090	-.016
	P.Value	.741	.185	.187	.183	.640	.489	.900
Iron	Correlation	.270*	.277*	.216	.340**	.191	.288*	.194
	P.Value	.035	.031	.095	.007	.140	.024	.135
Ferritin	Correlation	.329**	.342**	.083	.235	.237	.281*	.257
	P.Value	.010	.007	.525	.069	.066	.028	.046
**. Correlation is significant at the 0.01 level (2-tailed).								
*. Correlation is significant at the 0.05 level (2-tailed).								

Figure. 23

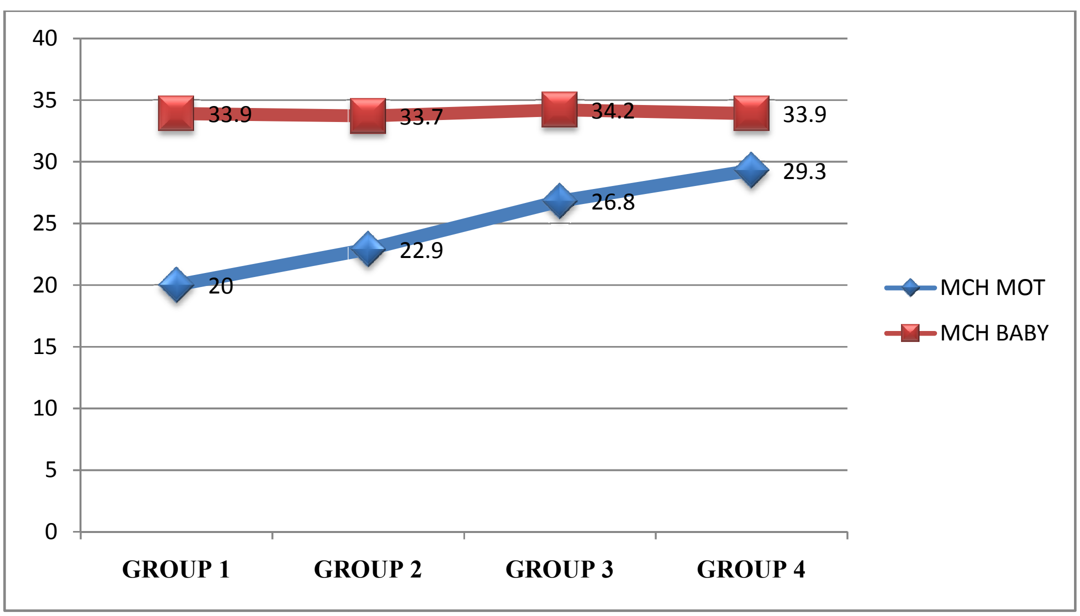
Correlation between the maternal MCV and MCV of the baby



This diagram shows that there is no correlation between the maternal and neonatal MCV levels.(P>0.05 In Table :23)

Figure.24

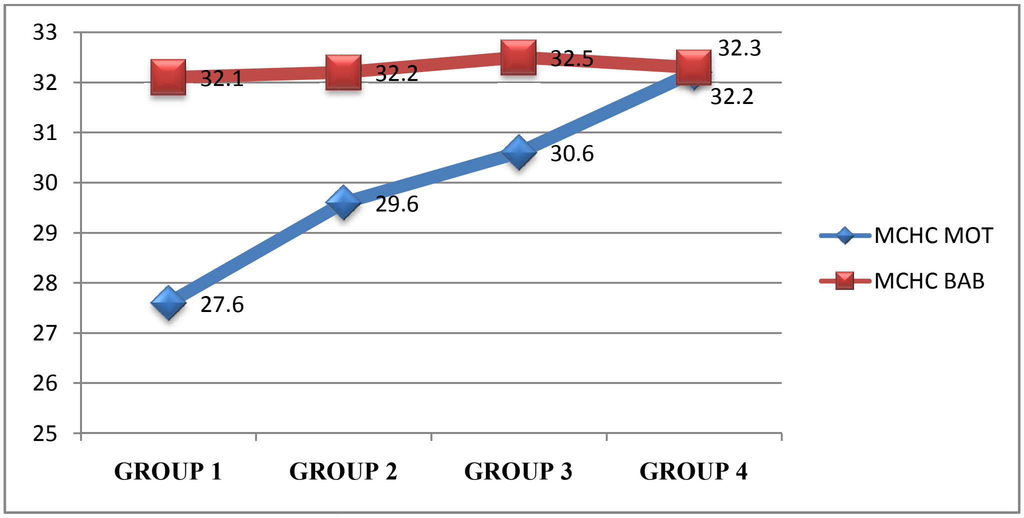
Correlation between the maternal and neonatal MCH



This diagram shows that there is no correlation between the maternal MCH and neonatal MCH values.(p>0.05 in Table:23)

Figure.25

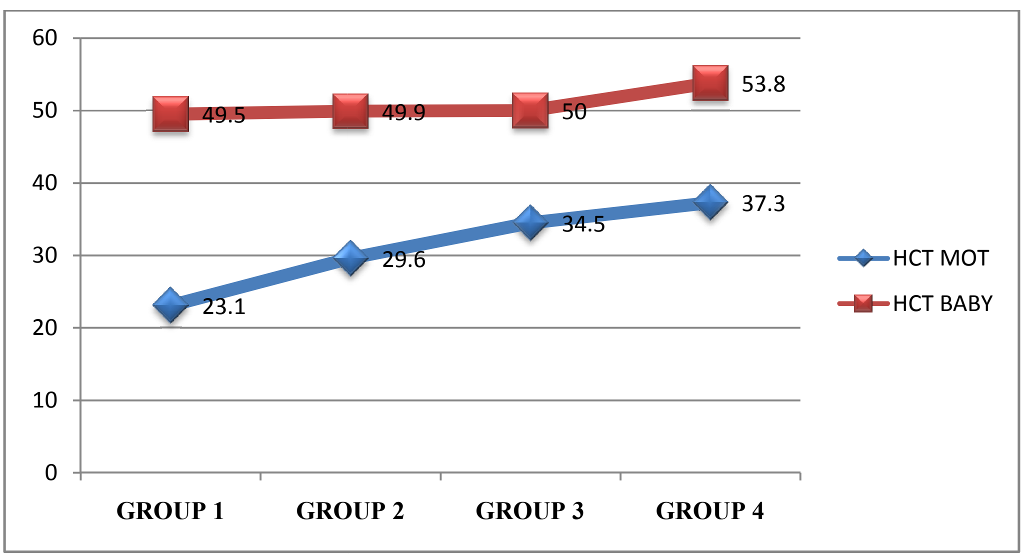
Correlation between the maternal MCHC and the neonatal MCHC



This diagram shows that there is no correlation between the maternal MCHC and neonatal MCHC.(P>0.05 In Table:23)

Figure.26

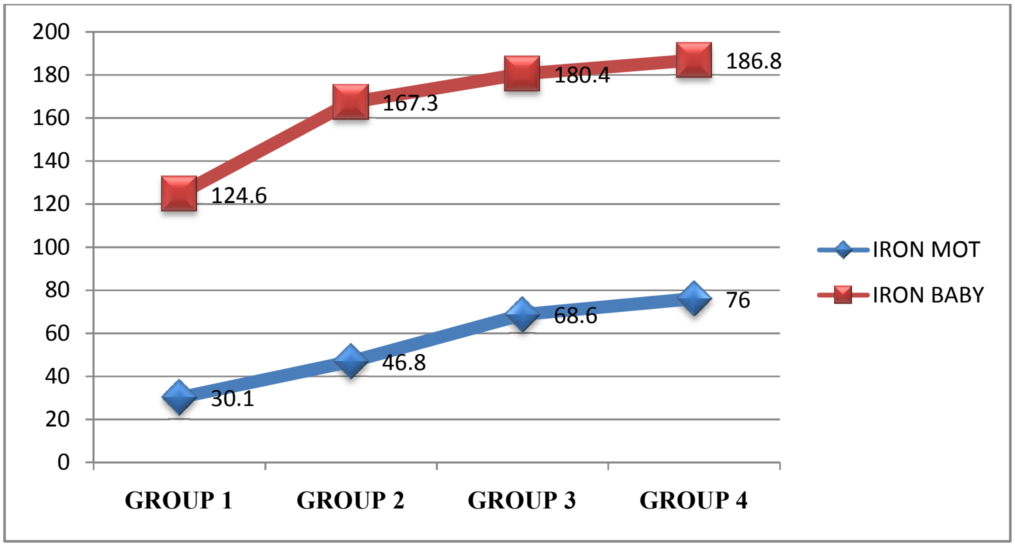
Correlation Between the Maternal Hematocrit and Neonatal Hematocrit



This diagram shows that there is a correlation between the maternal hematocrit and neonatal hematocrit values.(p<0.05 in Table :23)

Figure :27

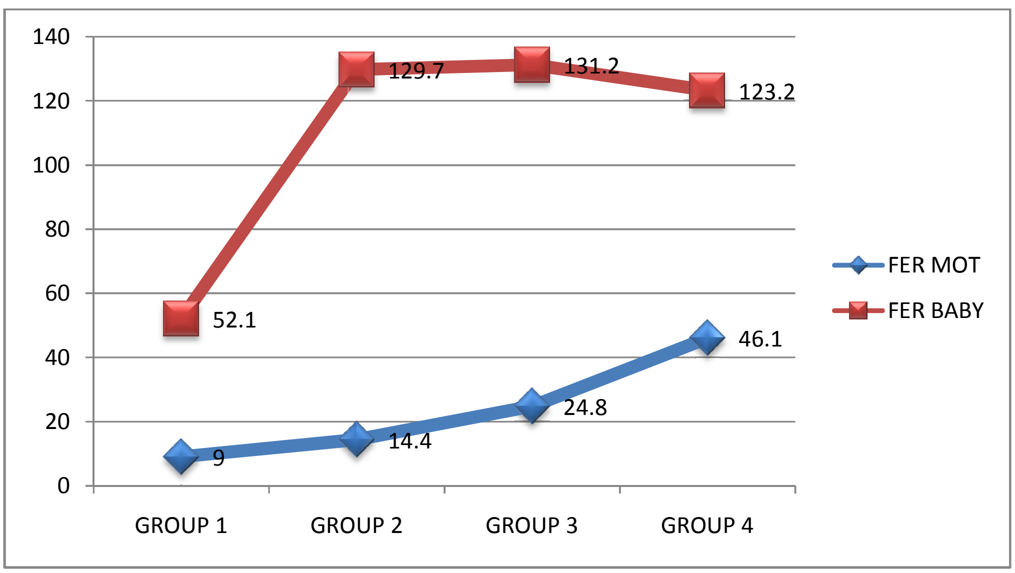
Correlation between the maternal iron and neonatal iron



This diagram shows a good correlation between the maternal iron and neonatal levels.($p<0.05$ in Table :23)

Figure.28

Correlation between the maternal ferritin and neonatal ferritin levels



This diagram shows that there is a positive correlation between the maternal and neonatal ferritin levels.($p<0.05$ in table:23)

Table.24

Hemoglobin levels in maternal and cord blood

Study group	Range of maternal hemoglobin g/dl	Hemoglobin g/dl mother	Hemoglobin g/dl cord blood
Group 1	≤6.9	6.36	15.8
Group 2	7-9.9	8.22	16.2
Group 3	10-10.9	10.53	16.3
Group 4	≥11	11.8	17.1

These values show that hemoglobin values are more in the cord blood than the maternal blood.

Table.25

Serum Iron Levels in Maternal and Cord Blood

Study group	Range of maternal hemoglobin g/dl	Serum iron mother Ug/dl	Serum iron cord blood ug/dl
Group 1	≤6.9	30.1	124.6
Group 2	7-9.9	46.8	167.3
Group 3	10-10.9	68.6	180.4
Group 4	≥11	76.0	186.8

These values show that serum iron values are more in the cord blood than mother.

Table.26

Serum ferritin levels in the maternal and the cord blood

Study group	**Range of maternal hemoglobin g/dl**	**Serum ferritin mother ng/ml**	**Serum ferritin cord blood ng/ml**
Group 1	≤6.9	9.0	52.1
Group 2	7-9.9	14.4	129.7
Group 3	10-10.9	24.8	131.2
Group 4	≥11	46.1	127.5

These values show that serum ferritin values are more in the cord blood than the maternal blood.

Table.27

Maternal and neonatal RBC indices

	MCV		**MCH**		**MCHC**	
Groups	**Mother**	**Baby**	**Mother**	**Baby**	**Mother**	**Baby**
1	75.8	107	20	33.9	27.6	32.1
2	73.9	109.4	22.9	33.7	29.6	32.2
3	82	106.4	26.8	34.2	30.6	32.5
4	88.8	106.2	29.3	33.9	32.2	32.3

This shows that the RBC indices values are higher in the cord blood than the maternal blood.

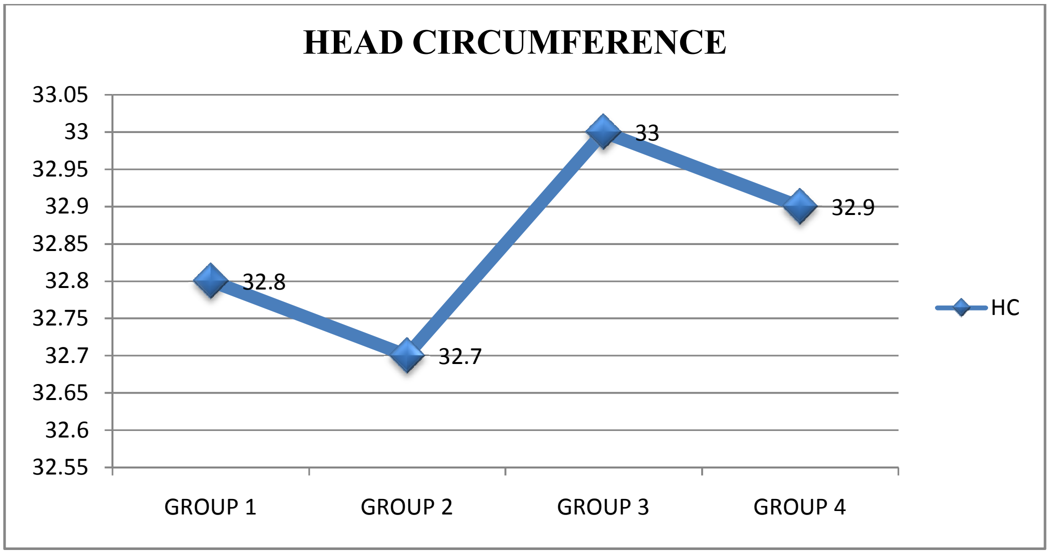
Table. 28

Anthropometric measurements of the baby

MOTHER HB CATEGORY		HC	LENGTH	CC	WEIGHT
≤6.9 gm%	Mean	32.800	50.000	30.000	2.5700
	Std. Deviation	.8367	2.6458	1.5811	.30332
7 - 9.9 gm%	Mean	32.762	50.000	30.548	2.7629
	Std. Deviation	1.3749	1.3784	1.7314	.42092
10 - 10.9 gm%	Mean	33.053	49.842	31.053	2.9992
	Std. Deviation	2.0131	2.1412	2.1206	.34126
≥ 11 gm%	Mean	32.963	49.906	31.075	2.7988
	Std. Deviation	1.2500	1.5080	1.7234	.31549
Total	Mean	32.908	49.926	30.798	2.8301
	Std. Deviation	1.5163	1.7460	1.8367	.37623

Figure.29

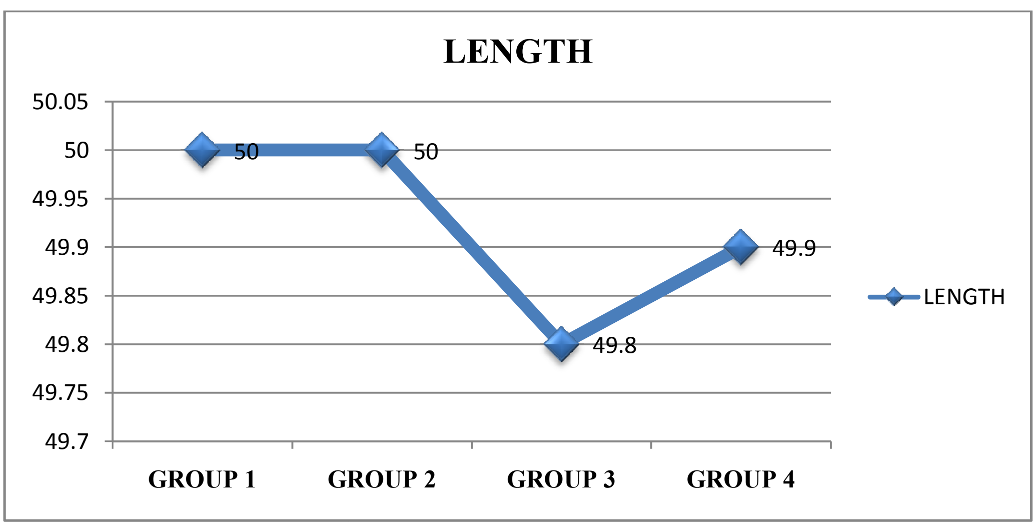
Line diagram showing the head circumfernce of the babies



This line diagram shows no correlation with the maternal hemoglobin levels.

Figure.30

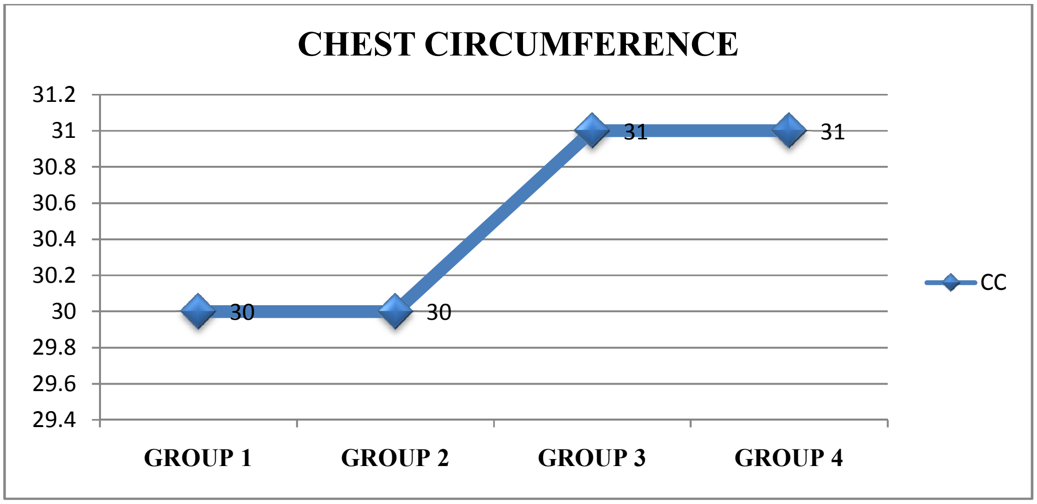
Line diagram showing the length of the babies



This line diagram shows that, there is no correlation of the length of the babies with the maternal hemoglobin levels.

Figure.31

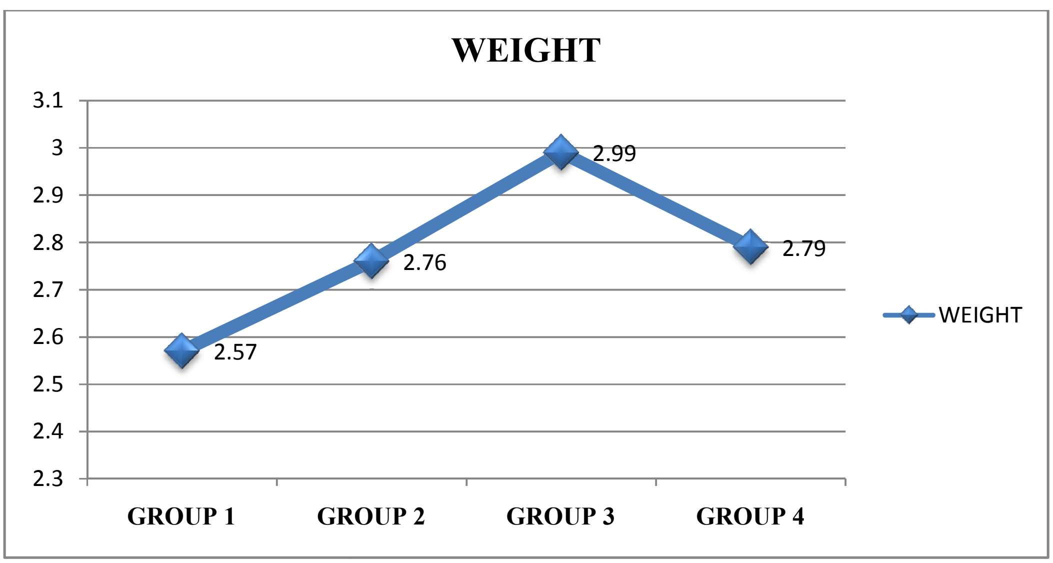
Line Diagram Showing the chest circumference of the babies



This line diagram shows that there is no correlation between the chest circumference of the babies and the maternal hemoglobin levels.

Figure. 32

Line diagram showing the weight of the babies



This line diagram shows that there is no correlation between the weight of the babies and the maternal hemoglobin levels.

Table. 29

Anova table showing the anthropometric measurements of the babies and its significant levels

			Mean Square	F	Sig.
HC * Mother HB category	Between Groups	(Combined)	.317	.132	.941
	Within Groups		2.403		
Length * Mother HB category	Between Groups	(Combined)	.094	.029	.993
	Within Groups		3.204		
CC * Mother HB category	Between Groups	(Combined)	2.320	.677	.570
	Within Groups		3.429		
Weight * Mother HB category	Between Groups	(Combined)	.331	2.514	.067
	Within Groups		.132		

From the above table, it is clear that none of the anthropometric measurements of the baby (head circumference, length, chest circumference and birthweight) shows a significant difference between the groups.($p>0.05$).

Table. 30

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
AGE	61	20	32	25.39	3.494
IRONTAB	61	10	120	49.52	27.330
IRONINJ	61	0	15	2.51	3.837
HC	61	29.0	36.0	32.908	1.5163
LENGTH	61	46.0	53.0	49.926	1.7460
CC	61	27.0	34.0	30.798	1.8367
WEIGHT	61	2.00	3.80	2.8301	.37623
MOT HB	61	5.9	13.6	9.890	1.7904
HCT	61	20.3	43.6	32.659	4.8800
MCV	61	62.6	100.2	80.525	8.6049
MCH	61	16.4	40.9	25.587	4.6616
MCHC	61	25.7	34.0	30.477	2.0805
IRON	61	22.3	142.0	59.913	26.5430
FERRITIN	61	6.9	70.8	25.557	17.2354
BABY HB	61	14.2	20.5	16.508	1.4605
HCT	61	35.6	63.0	50.954	5.3182
MCV	61	96.8	120.0	107.502	4.9347
MCH	61	28.3	37.7	33.982	1.9242
MCHC	61	28.5	35.9	32.370	1.5613
IRON	61	45.0	260.0	173.043	55.6157
FERRITIN	61	42.3	234.0	123.292	49.2413

DISCUSSION

Iron deficiency anemia is the most common nutritional deficiency disorder affecting the pregnant women in our country with a significant impact on maternal and fetal mortality and morbidity.

In the present study, 75 pregnant women were selected based on the inclusion and exclusion criteria. Out of 75 women, 14 had hemoglobin values less than 11 with normal iron stores pointing towards other causes of anemia and they were not included in the study. The remaining 61 pregnant women were divided into four groups depending on their hemoglobin values according to the classification of anemia in pregnant women by Indian Council of Medical Research.

Pregnant women with severe anemia (hemoglobin ≤6.9g/dl) constituted group 1 and it contained 5 pregnant women (8.2%).

Mothers with moderate anemia (hemoglobin 7-9.9g/dl) constituted group 2 and it contained 21 pregnant women(34.4%).

Pregnant women with mild anemia (hemoglobin 10-10.9g/dl) constituted group 3 and there were19 women in this group which constituted 31.1% of the sample size.

Pregnant women with hemoglobin values ≥11g/dl constituted group 4 and there were 16 women in this group comprising 26.3% of the sample size.

The prevalence of anemia (hemoglobin <11g/dl) (59 out of 75) in the present study group is 78.7%, which is comparable with the values in the following studies.

Table.31

Prevalence of anemia in pregnant women in various studies

Studies conducted by	Prevalence of anemia
ICMR task force study 1989[19]	88%
Koen et al 1991[51]	76%
Ministry of Health and Family welfare1989[52]	77%
Ezzati et al 2002 in India	87%
Brabin et al in mumbai 1998[53]	79.6%
Jolly Rajaratinam et al in vellore 1996[54]	69.3%
The present study	78.7%

Values of hemoglobin, serum iron and serum Ferritin in maternal and cord blood

In general, the iron related parameters are higher in the cord blood, compared to the maternal blood. The present study also corroborates this finding in some of the parameters. The values of hemoglobin, serum iron and serum ferritin in the cord blood were higher than the maternal blood. Similar results were obtained in the studies conducted by

Kumar et al in India[55],

Adriana et al in Brazil [56]

Emamghorashi et al in Iran[57] .

K.V. Shyamala et al in mangalore[58]

The mean corpuscular volume, mean corpuscular hemoglobin, mean corpuscular hemoglobin concentration were higher in the cord blood compared to the maternal blood.

Similar results were obtained in the studies done by Lao et al and K.V.Shyamala et al.

Correlations between the RBC indices and Iron stores of the mothers with respect to their Hemoglobin levels:

MCV values of the mothers showed a weak correlation with the maternal hemoglobin levels. Between the 4 groups, MCV values of the mothers showed a significant difference, i.e. mean corpuscular volume changed with respect to the severity of anemia.

MCH showed a linear rise with respect to the hemoglobin values in the pregnant women. There is a significant difference between the four groups of women in MCH values, i.e. the Mean Corpuscular Hemoglobin values changed with respect to the severity of anemia.

MCHC values also showed a linear relationship with the maternal hemoglobin values. There is a significant difference between the four groups studied. The Mean Corpuscular Hemoglobin Concentration bend to change with respect to the severity of anemia.

Serum Iron and Serum Ferritin values of the mothers showed a linear relationship with their hemoglobin levels and there was a significant differences between the four groups studied. The serum iron and ferritin values bend to change with respect to the severity of anemia.

Correlation between the maternal Hemoglobin and the Neonatal Hemoglobin

Statistical analysis of the obtained data, to find out the significance of correlation,revealed that there is a positive correlation between the maternal and neonatal hemoglobin levels in the four groups. Although the mean hemoglobin of babies in all the four groups were in the normal range, the mean hemoglobin rises with respect to the maternal hemoglobin levels without any statistical significance.

Similar results were obtained in the study conducted by Kamath et al[59] in Kasturba medical college.

In the study conducted by Shyamala et al , in Mangalore there was no significant difference in the neonatal hemoglobin levels between the case group(neonates of anemic mothers) and the control group (neonates of non-anemic mothers). But they divided the mothers into two groups (anemic and non-anemic). In another study conducted by Ziaei et al [60], in Iran they have found a significant difference in the neonatal hemoglobin between the three groups.(anemic, iron-deficeint, non-anemic and non iron-deficient).

In the studies conducted by Emamghorashi et al in Iran and in the study conducted by Adriana et al in Brazil they found no correlation between the maternal and neonatal hemoglobin levels.

Table.32

Studies on correlation between the maternal and the neonatal hemoglobin levels

	Positive correlation	No correlation
Studies	Kamath et al Kumar et al The present study	Emamghorashi et al Adriana et al

The results of the present study are similar to the studies conducted in India. The other two studies which is against this view were conducted in other countries.

The hemoglobin values of the babies in all the four groups were in the normal range. But they showed a correlation with the maternal hemoglobin levels.

In the study , conducted by Kumar et al in Varanasi he took many women with severe anemia and he got a similar result.

Table. 33

Significant difference in the hemoglobin values of the neonate with respect to the maternal hemoglobin levels:

	Significant difference	No significant difference
Studies	Ziaei et al Kumar et al	Kamath et al Shymala et al The present study

Even though the hemoglobin values of the babies showed a correlation with the maternal hemoglobin values, they do not show any statistical difference between the four groups in present study,i.e. the hemoglobin values do not fall or rise with the severity of anemia. Similar results were obtained in the two studies conducted by Kamath et al. and Shymala et al. in India.

In this regard, the results of the study conducted by Kumar et al. is contradicting the present study.

Correlation between the neonatal RBC indices with the maternal hemoglobin levels:

The mean value of MCV, MCH and MCHC in the neonates in all the four groups do not show any significant relationship with respect to the maternal hemoglobin levels.

Table.34

Correlation of the RBC indices of the neonate with the maternal hemoglobin levels:

	No correlation	**Positive correlation**
Studies	Jordan et al Kilbride et al The present study	Kamath et al (except MCHC) Shymala et al (except MCHC)

In this regard , the results of the present study is contradicting the Indian studies.

Correlation between the serum iron and Ferritin levels of the neonates with the maternal hemoglobin levels:

The mean serum iron and serum ferritin values of the neonates showed a positive correlation with the maternal hemoglobin levels with statistical significance. (serum iron p 0.035, serum ferritin p 0.010), whereas serum ferritin showed a significant difference between the groups than serum iron. The serum ferritin level was very low in the group of newborns born to severely anemic mothers compared to the other three groups.

Multiple studies have been conducted throughout the world to find this correlation with varying results . The results of the present study in this regard, is similar to the Indian studies.

In a case –control study by Kilbride et al. carried out in Jordan, he investigated the relation ship between the maternal anemia and neonatal iron status at birth, 3-4, 6, 9and 12 months of age. He did not find any correlation between the maternal anemia and neonatal iron status.

In the studies by Rios et al., Kelly et al. and puolakka et al. no significant correlation was found between the maternal anemia and the umbilical cord ferritin levels.

Table.35

Correlation of serum iron and serum ferritin values of neonates with the maternal hemoglobin levels

Studies	**No correlation**	**Positive correlation**
	Kilbride et al Rios et al[6] Kelly et al[4] Puolaca et al[11]	Adriana et al Kamath et al (serum iron) Shymala et al(serum iron) Kumar et al Agrawal et al The present study

In this regard, the results of the present study were similar to the results of the other studies conducted in India.

Correlation between the maternal and neonatal RBC indices:

The MCV values of the neonate showed a negative correlation with the maternal MCV which was not significant.(correlation -119 ,p 0.3 in table23).

The MCH values of the neonate showed a positive correlation with the maternal MCH values which was significant .(correlation 0.295, p 0.021 in table 23).

The MCHC values of the neonate showed no correlation with the maternal MCHC values (correlation 0.061, p 0.6 in table 23)

Correlation between the maternal and neonatal Iron stores:

Serum iron values showed a significant correlation between the mother and the neonate.(p 0.024).

In the study by Shyamala et al., they have reported that the mean serum iron in the cord blood of anemic mothers was less than the serum iron in the cord blood of non-anemic mothers.

However, in the studies conducted in other countries, they have reported no significant difference between the serum iron levels in the cord blood of anemic and non-anemic mothers.

Table.36

Studies on the correlation between the maternal and neonatal Iron :

	Positive correlation	No correlation
Studies	K.V.Shyamala et al	Kilbride et al
	Kumar et al	Adriana et al
	Kamath et al	Rosely et al[61]
	The present study	Emamghorashi et al

The results of the present study were similar to the results of the other studies conducted in India.

Correlation between the maternal and neonatal Serum ferritin values:

Serum ferritin levels showed a positive correlation between the maternal and neonatal blood with statistical significance ($p<0.05$). There is a significant difference in the serum ferritin values of the cord blood of the babies in the four groups.

This shows that the serum ferritin levels on the cord blood vary depending on the severity of maternal anemia.

Table.37

Studies on serum Ferritin Levls Correlation:

	Positive correlation	No correlation
Studies	Kumar et al Emamghorashi et al The present study	Rios et al Puolakka et al Kilbride et al Kelly et al

The results in the present study were similar to those of the Indian study conducted by Kumar et al in Varanasi.

Iron is actively transported from the pregnant women to the fetus. In women with iron-deficiency, there is upregulaion of some proteins transporting iron in the placenta. This ensures adequate supply of iron to the growing fetus. This explains higher iron and ferritin values in the cord blood, compared to the maternal blood, even in mothers with severe iron-deficiency. However, the linear relationships of iron and ferritin levels of the cord blood with the maternal hemoglobin, iron and ferritin levels show that the fetus accumulates iron in direct proportion to the levels available in the mother. Thus it seems placental iron transport mechanisms are not inviolate, and in cases with severe anemia these mechanisms might fail, leading to an insufficient iron supply to the fetus.

Correlation of the anthropometry of the neonate with the maternal hemoglobin levels

For evaluating the effect of maternal iron deficiency on neonates, some neonatal parameters like birth weight, length, head circumference and chest circumference were considered as growth indices.

Scholl et al. showed that pregnant women with iron-deficiency anemia had a three times increased risk of giving birth to neonates with low birth weight.

In contrast, in a study by Preziosi et al, no significant difference was found between birth weight of the neonates and the maternal iron status. The effect of iron deficiency in mothers on fetal growth has been reported to be significant especially in the teenage mothers.

Micronutrient consumption during pregnancy has an significant impact on the neonatal growth and development. Pregnant women who received iron supplements have been reported to have heavier babies by Cogswell et al.

The present study does not show a correlation between the neonatal birth weight, head circumference, length and chest circumference with the maternal hemoglobin levels. The birth weight of the babies shows a linear relationship with the maternal hemoglobin levels in the initial three groups (anemic women). Whereas in the non-anemic women , the birth weight of the babies is somewhat lower than the babies in the mild anemic groups. Eventhough there is no correlation of birth weight, with the maternal hemoglobin levels, the birth weight of the babies born to mothers with severe anemia was at a lower range compared to the mothers in the other three groups (moderate, mild and normal pregnant women) .

In the study by Emamghorashi et al. they have reported a significant correlation between the neonatal head circumference and the maternal anemia.However, they did not report any correlation between the birth weight and the maternal anemia.

Table.38

Studies on correlation of birth weight with maternal hemoglobin levels

	Positive correlation	**No correlation**
Studies	Scholl et al[3] Kamath et al.	Preziosi et al[62] Emamghorashi et al The present study

LIMITATIONS OF THE STUDY

1. This study considered some parameters used to assess iron-deficiency like hemoglobin, RBC indices, serum iron and serum ferritin. But other parameters like total iron binding capacity (TIBC), Erythrocyte protoporphyrin , Transferrin saturation (percentage) were not considered.
2. Maternal iron status was not assessed from early pregnancy, which would be more meaningful in assessing the effects on the fetus. However, it was not possible to do so ,because none of the pregnant women were registered in the first trimester and they attended our hospital for the first time only during delivery. Moreover, it would have been unethical to study from early gestation without supplementing them with iron.

CONCLUSION

From the above findings, it is obvious that a positive correlation exists between the maternal and the neonatal hemoglobin levels. Even though the hemoglobin values of the babies falls in the normal range , their values show a correlation with the maternal hemoglobin levels.

The RBC indices of the baby (MCV, MCH, MCHC), do not correlate with the maternal hemoglobin levels

The serum iron and serum ferritin values of the neonates correlate with the maternal hemoglobin levels and serum ferritin are very low in the neonates of the mothers with severe iron –deficiency.

The birth weight of the babies do not correlate with the maternal hemoglobin levels. But comparing with the babies of the mothers with normal hemoglobin levels, the babies of the mothers with severe anemia show a low birth weight.

The neonates of both anemic and non-anemic women may be born with a hemoglobin in the normal range but the iron stores of the neonate depends on the maternal iron status. The iron available for erythropoeisis is low in the babies of anemic mothers than non-anemic mothers. Whatever iron available for them is utilized to keep the hemoglobin in the normal range and not used for building up the iron stores.

The lower iron and ferritin values of the neonate were not reflected by the neonatal RBC indices, hence they should not be used as a indicator for assessing the iron status.

The low iron stores of the neonates may be depleted easily, when the demands are high in early infancy. Iron deficiency in early life may have long term adverse effects on the cognitive development and may also impair cellular immunity. Thus the deleterious effects of maternal anemia extend far beyond pregnancy and early infancy. Effective strategies are needed to control maternal anemia in the developing world. Improving the iron status of pregnant women by improving the nutrition as well as the regular intake of iron supplements will have a favorable impact on maternal, fetal and infant iron nutrition. Another approach to improve the iron status of the neonates is to delay the clamping of the cord after birth[54]. In conclusion, the data of the present study indicate that maternal iron-deficiency adversely affects the cord blood iron status.

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PROFORMA

Name:

Age:

Parity:

IP No:

LMP: EDD:

Address:

Phone no:

Educational status of mother

Educational status of father

Mother working non-working

Socioeconomic status of family

Order of birth

Booked Unbooked

Antenatal iron tablets

Iron injection

Admitted with c/o

Examination

Baby Anthropometry : Head circumference: Length:

Chest circumference:

Birth weight of baby

Investigations:

(Mother)

Hemoglobin:	MCV:	MCH:	MCHC:
Serum Iron:	Serum Ferritin:		

(Baby)

Hemoglobin:	MCV:	MCH:	MCHC:
Serum Iron:	Serum ferritin:		

AGE	PARITY	ADDRESS	EDUMOT	EDUFAT	OCCUPAT	SESTATUS	ANCARE	IRONTAB	IRONINJ	AD FOR	HC	LENGTH	CC	WEIGHT	MOT HB	HCT	MCV	MCH	MCHC	IRON	FERRITIN	BABY HB	HCT	MCV	MCH	MCHC	IRON	FERRITIN
											cm	cm	cm	kg	gm/di		fl	pg	g/dl	ug/dl	ng/ml	gm/dl		fl	pg	g/dl	ug/ml	ng/ml
21	primi	Ambasamudram	4 std	10th std	nw	3000/-	booked	15	5	referral	33	53	32	3	5.9gm	26.1	72.9	19.3	26.4	30.8	7	15.3	46.7	109.6	35.9	32.8	236	74.8
21	primi	tvl town	10 std	_	nw	4500/-	booked	40	_	labour	33.5	48.5	31	2.47	13.6	43.6	84.7	26.4	31.2	137	54.2	19.9	61.9	107.8	34.7	32.1	98	116.4
32	g2p1l1a1	ktc nagar	B.COM	12thstd	nw	10000/-	booked	50	_	safe cfnt	33	52	30	2.85	13	39.4	92.9	30.7	33	126.4	31.86	17.3	52.4	100	33	33	242	127
26	g2p1l1a0	market	5 std	10thstd	nw	3000/-	booked	30	5	safe cfnt	35	52	32	3.1	11.1	34.5	96.1	30.9	32.2	48.1	20.54	20.5	61.5	105.9	35.3	33.3	230	107.3
27	g2p1l1a0	melapalayam	8thstd	8thstd	nw	4000/-	booked	30	_	safe cfnt	34	53	32	3.8	7.8	27.5	68.4	19.5	28.4	47.3	14.27	18.2	58.2	107.2	33.3	34	210	51.43
22	primi	sankarankovil	5thstd	_	nw	1500/_	booked	15	_	safe cfnt	29	48	27	2.8	10.8	35.8	80.4	40.9	32.2	65.3	14.3	17.3	52.3	105.7	35.8	35	244	77.6
20	g2a1	alangulam	10thstd	10thstd	coolie	5000/-	booked	40	_	safe cfnt	32	50	31	2.5	12.9	37.3	86.9	28.5	32.8	77.8	50.2	17.3	52.9	104.3	34.1	32.7	231.2	102.3
22	g2p1l1	malayankulam	5thstd	10thstd	coolie	4500/_	booked	45	_	safe cfnt	32	49	29	2.45	10.3	32.7	80.5	25.4	31.5	113	14.4	17.3	54	103.3	35.2	32.6	198	123
30	g2p1l1	thatchanallur	6thstd	7thstd	nw	6000/_	booked	70	_	safecfnt	32	47	31	2.6	10.6	33.1	84	26.9	32	132	20	15.4	47.7	109.7	34.2	30.2	175	100.3
24	primi	urkadu	4thstd	10thstd	coolie	3000/_	booked	60	_	safecfnt	34	50	31	2.6	11.7	38.2	89.7	25.5	30.6	82.3	32.3	18	53.4	100.8	34	33.7	244	150.2
26	g2p1l1	thoothukudi	10thstd	12thstd	nw	8000/_	booked	100	_	safecfnt	32	50	32	3.12	7.4	26.4	62.6	17.5	28	40	15	14.3	35.6	103.2	33.2	32.3	165	154
26	g2p1l1	thimmarajapuram	B. Com	I.T	shopkee	10,000/_	booked	90	_	safecfnt	36	51	34	3.45	10.6	34.2	85.5	26.5	31	56.2	12	16.3	50.8	105.6	32.4	34	248	196
22	primi	mathalamparai	8thstd	_	nw	2500/_	booked	90	_	safecfnt	34	50	33	2.9	12.1	38.1	82.6	26.9	32.5	70.2	55.5	14.7	45.9	104.3	33.4	32	133.6	98.4
22	primi	kadayam	10thstd	8thstd	nw	15000/_	booked	90	_	referral	34	50	31	2.45	7.3	27	74.4	20.1	27	45	10	16.5	49	113	32.2	34	210	132
30	primi	vannarpettai	10thstd	7thstd	nw	5000/_	booked	30	_	safecfnt	34	52	32	3.725	10.4	34.9	80.2	23.9	29.8	56	15.7	16.4	50.3	112.1	33.2	34	205.3	124.2
27	g2p1l1	Ambasamudram	9thstd	10thstd	nw	2000/_	booked	25	10	referral	34	49	30	2.95	9.4	31.3	84.2	24.5	29.2	62	15	15.4	46	111	34	33	123	78
21	primi	achankovil	B.A	12thstd	tailor	7000/_	booked	25	_	safecfnt	31.5	47	27	2.3	11.8	38.7	89.8	29.7	33.1	61.3	44.7	18.5	62.3	108.3	34.3	31.6	100.3	77.9
22	primi	vannarpettai	_	10thstd	nw	3000/_	booked	10	10	referral	31	51	27	2.3	7.1	26.4	64.7	17.4	26.7	43	8	15.4	47	103.6	28.3	30	90	60
29	primi	uvari	_	5thstd	coolie	4000/_	booked	50	4	referal	31	52	29	2.9	10.6	33	93.4	26.5	28.4	57	20.2	15.5	47.7	102.7	35.6	32.2	221	145.3
30	g2a1	market	10thstd	12thstd	coolie	65oo/_	booked	50	3	referral	36	51	34	3.6	10.9	38.3	85.8	24.1	28.3	142	32	17.2	51.2	102.3	34	34	176	145.2
20	primi	thoothukudi	8th std	5thstd	nw	6000/_	booked	45	_	referral	32	51	28	2.3	6.5	22	85.8	18.4	25.9	22.3	14	16.3	50.9	114.4	37.7	32.4	102.9	55.6
22	g2p1l1	kayathar	10thstd	_	coolie	5000/_	booked	60	5	referral	32	50	30	2.5	7	24.3	63	18.1	28.8	32	15	14.2	44.3	114.2	29	34.4	165	98
25	primi	tirunelveli	12thstd	4thstd	nw	5500/_	booked	20	_	safecfnt	33	51	32	3.1	10.6	34.7	89.7	27.4	30.5	55	30	15.2	46	102.3	35.9	32.8	143	50.2
22	g2a1	thoothukudi	5thstd	5thstd	nw	1900/_	booked	45	8	referral	31	50	28	2.5	9.2	32.9	74.9	20.9	28	56	12.8	16.7	50.2	98.9	32	34.2	176.2	155.2
26	g2p1l1ao	v.k.pudhur	12thstd	_	beediwo	4500/_	booked	70	_	referral	33	49	31	3.05	11.5	36.7	92	29.8	31.3	85.5	59.6	17.3	52.9	104.3	34.1	32.7	211.1	78.8
21	primi	villapuram	12thstd	12thstd	shopkee	6000/_	booked	90	_	safecfnt	34	52	32	2.6	9.6	32.6	77.3	22.7	29.3	59.2	14.4	18.3	58.3	111.6	36.4	31.1	162	119.8
26	g2p1l1	urkadu	B.Sc	B.Com	nurse	10000/_	booked	90	2	safecfnt	36	53	34	3.16	10	32.5	80	28	32	42	20.2	14.9	48.3	109.2	30.8	32.6	162.3	154
22	primi	achankovil	B.A	B.Com	tailor	8500/_	booked	70	5	referral	34	49	32	2.6	8.9	29.5	64.8	19.6	27.1	50.2	15.5	16.5	53.2	116.5	36.2	29.9	145.2	142
30	primi	srivaikundam	10thstd	10thstd	nw	5000/_	booked	30	5	referral	35	51	32	2.9	10.7	36.2	79.7	23.4	29.7	52	30	16.4	50.9	114.4	37.7	32.4	100	154
29	g2p1l1a0	thiruchendhur	12thstd	1othstd	nw	6000/_	booked	30	_	referral	34.4	51	32	2.85	11.2	37.4	88.5	29	32.7	49.5	24.9	18.1	62	108.3	34.3	31.6	90.2	86.2
23	g2p1l1a0	ambai	12thstd	12thstd	coolie	3500/_	booked	90	_	safecfnt	31	46	28	2.9	10.5	35.4	79.5	23.5	29.7	54	23	14.9	47.6	109	34.3	31.3	125	176
26	g2p1l1	ariyapuram	4thstd	12thstd	coolie	5000/_	booked	25	10	safecfnt	33	51	33	2.95	9	32	75.8	21.3	28.1	46.7	20	19.7	62.3	108.3	34.3	31.6	205	139
25	primi	puliarai	B.A	B.A	merchant	6500/_	booked	70	_	safecfnt	34	51	33	2.5	10.1	32.5	86	26.7	31.2	49.2	35	17.4	53	105.2	34.5	32.8	250	66.7
28	primi	pappakudi	7thstd	3rdstd	farmer	5000/_	booked	45	_	safecfnt	35	50	33	2.75	9.8	32.7	79.7	27.7	30	60	13.5	14.6	47.2	108	35.5	31	243	202
30	g2p1l1	ambai	12th	5thstd	beediwo	5000/_	booked	60	_	safecfnt	30	47	28	2.15	11.1	38.3	87.2	28	31.4	77	60.2	19.4	63	108	32.6	35	245	156.6
22	primi	sankarankovil	_	_	servant	4800/_	booked	50	_	safecfnt	34	50	32	3	11.1	37	86	30	32.2	64	55.6	16.9	49.5	111.3	33.4	35	200.3	119.6
23	primi	nanguneri	9thstd	12thstd	nw	5000/-	booked	60	_	safecfnt	33	49	32	2.7	9.9	33.7	72	28.8	31.2	53	20	15.5	46	103.4	35.2	32	165	202.3
21	primi	tenkasi	3rdstd	12thstd	nw	5500/_	booked	20	10	referral	34	46	31	2.9	10.5	35.1	68.3	20.4	29.9	32	15	18.7	57	96.8	31.7	32.8	100	42.3
29	g2p1l1	sankarankovil	5thstd	_	nw	3000/-	booked	120	_	referral	30	48	27	2.8	8.1	27.2	72.1	21.3	29.8	29.6	8.2	15.9	48	98	30	32	45	132
22	g2p1l1ao	nanguneri	4thstd	_	nw	3000/_	booked	70	_	referral	32	49	31	3.3	10.9	36.5	91.4	27.5	28.8	50	43	17.3	51.2	104.5	35.1	32.7	121	77.6
30	primi	melapalayam	6thstd	8thstd	nw	1500/_	booked	90	_	safecfnt	32	51	30	2.3	9.5	28.1	79.2	26.8	33	54	11	17.1	52	111	33	31.2	126	202.3
30	primi	tvl	10thstd	8thstd	nw	6000/_	booked	10	_	referral	31	50	28	3.1	10.2	31.5	78.2	28.6	32.4	54	9.8	15.4	47	108.9	36.2	33.2	145	92
28	primi	muthaipuram	9thstd	8thstd	nw	4000/_	booked	40	_	referral	34	51	31	2.75	6.4	20.3	79	23.4	31.2	35.4	6.9	14.2	47	103.5	32.6	31.5	92	42.6
23	g2p1l1	shencottai	10thstd	12thstd	nw	4000/_	booked	20	10	referral	33	46	30	2.5	6.1	23.7	63.5	16.4	25.7	32	7.3	16.2	48.7	102.3	30	32	90	42.3
23	primi	melapalayam	12thstd	B.A	nw	8000/_	booked	90	_	safecfnt	35	50	33	2.8	10.9	37.7	76	22	28.9	62.3	55.6	17.2	51.3	109	33	32.4	149	221
23	g2p1l0	ambai	10thstd	8thstd	nw	1200/_	booked	70	_	safecfnt	33	48	31	2.8	10.9	33.7	80.2	30.2	32	65	50.2	16.2	48.2	102.3	33	30	230	165
22	primi	nanguneri	5thstd	_	nw	4500/_	booked	90	_	safecfnt	33	50	32	2.8	11.8	38.7	100.2	30.9	34	67.8	30.8	16.5	54.7	110	33.5	29.8	210	154
27	g2a1	ambai	_	5thstd	coolie	3000/_	unbooked	10	1	referral	32	49	29	2.3	6.9	23.7	78.2	22.8	29.1	30	10	17.2	54.3	108.2	33.4	32.1	102.3	45.2
30	g2p1l1	nanguneri	5thstd	7thstd	nw	1500/_	booked	10	15	referral	32	52	30	2.8	9.3	32.6	71.8	21.8	28	50	23.9	14.9	46	112	34	32	200	132
27	g2a1	ambai	B.com	12thstd	shopkee	6500/_	booked	50	5	referral	33	51	34	3.2	11.3	34	88.7	32	33.6	80	67.6	15.6	45	103.4	33.4	32	190	234
24	primi	sankarankovil	5thstd	7thstd	nw	5500/-	booked	45	_	referral	32	49	30.2	2.76	11.4	34	79.6	27.6	32	54	44.3	15.4	46.3	112	34.2	32	230	134.9
29	primi	shencottai	10thstd	6thstd	nw	1000/_	booked	50	10	referral	34	48	30	3.4	9.5	31.3	65.3	19.8	30.4	42	20	16.6	50	120	36.5	32	260	145
20	primi	muthaipuram	12thstd	2ndstd	nw	1500/_	booked	20	_	referral	32	48	30	2	8.7	27.4	86.4	27.4	31.8	45	14.6	17.2	53.4	119	37.2	35	142	97
24	primi	sarathapuram	diploma	10thstd	nw	3000/_	booked	20	_	referral	31	51	30	3	9	30.7	83.9	26.2	31.3	30.2	13.6	16.7	52.5	113	35	34.5	150	126
26	primi	ramayanpatti	5thstd	9thstd	coolie	7000/_	booked	50	2	safecfnt	33	51	32	3.15	12	38.5	89.5	34	32	90.7	70.8	16.6	52	107.5	33.8	31	243	194
30	g2a1	alangulam	7thstd	10thstd	coolie	2500/_	booked	40	7	safecfnt	34	49	31	2.5	7.3	24.2	74	22.3	30.2	56.9	13.7	14.8	47	103.5	32.6	31.5	157	92
29	g2p1l1	town	3rdstd	10thstd	nw	3000/_	booked	45	5	referral	33	49	31	3	10	34.6	82.3	28.1	31.8	102.3	12.1	16.5	50	111	35.6	34	238	230
30	primi	kovilpatti	_	10thstd	nw	2500/_	booked	20	_	referral	32	51	31	3.1	11.8	33.4	86.7	28.9	32	45	34.5	15.5	46	103	34.4	30	90.7	103.4
30	g2p1l1	kadayam	_	11thstd	coolie	4500/_	booked	70	4	safecfnt	32	50	29.5	3.4	9.8	30.8	79.8	28.8	31.8	39.2	10.6	17.9	56.2	109.6	35.2	31.2	230	155.2
23	primi	kadayam	_	10thstd	nw	3000/_	booked	50	2	safecfnt	31	53	30	3	10.6	33.6	78.3	29.2	32	65	20.1	15.2	46	109	33	34	198	154
29	g2p1l1	nanguneri	6thstd	12thstd	nw	5000/_	booked	16	10	referral	34	49	32	2.6	8.4	34	77.8	30	34	42	14.5	15.6	46	112.4	36.5	35.9	145	109.7